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Part I

CONSTRUCTION

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[redacted]

[redacted] of a two-stroke, multi-diesel, turbo-supercharged, remote-controlled, single-[redacted] with [redacted] of wedge-shaped, opposite-moving pistons, four crankshafts, [redacted] and interconnected [redacted] of air.

[redacted]

[redacted] model	61D-2
[redacted]	26ДШН
[redacted]	23
[redacted]	2x30
[redacted]	6,000
[redacted] rated power, [redacted]	850
[redacted] speed of power take-off	
[redacted]	350
[redacted]	230
[redacted]	300
[redacted]	16
[redacted] rated [redacted]	8.5
[redacted] rated power	8.0
[redacted]	clockwise
[redacted]	from turbo-supercharger:
	cylinders 1 to 8 on the right-hand row;
	cylinders 9 to 16 on the left-hand row

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shaft of fuel injection pump, lubricating pump, governor, rpm-meter, overspeed governor, and fuel feed limiter. The fuel feed pump is installed on the side of the rocking lever parts.

The drive bonding side walls holds the emergency control station and control selector switch (on one side), the shaft bearing arrangement (on the other side), and the fuel filters (on both sides).

The drive for major gear sump oil pump, fresh and sea water pumps and turbo-supercharger attached to it is secured as an independent unit to the frame bow and fore. The power consumed by the supercharger exceeds the power of the gas turbine, and, therefore, the turbo-supercharger has an additional drive from the diesel engine.

The scavenging-supercharge air goes from the supercharger into the coolers located along the diesel-engine sides, whence it flows into the scavenging air receiver.

The engine is operated from the remote control panel placed beyond the diesel engine. The engine is provided with an emergency control station and with a selector switch to change over the control from the remote control panel to the emergency control station, and vice versa.

An overspeed governor is available on the diesel engine to cut out the fuel injection pumps in case the crankshaft speed exceeds the permissible ranges.

The diesel engine is provided with automatic thermal regulation of fresh cooling water and lubricating oil, and with an automatic warning signalling system.

The thermoregulators, water and oil coolers, and oil filters are mounted beyond the diesel engine.

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Chapter 11

DIESEL ENGINE FRAME AND COVERINGS

The welded frame is the diesel engine main unit that carries the working loads and unites all the engine parts into a common structure.

A covering closes the frame on top, while the sump closes it at the bottom.

DIESEL ENGINE FRAME

The diesel engine frame (Figs 1a, 1b, 1c) comprises vertical lateral walls 5, horizonal shelves 19, side plates 17 and 20, upper lugs 14, lower lugs 22 and air receiver 18, all welded into a common structure.

Horizonal shelves 19, each provided with centering collars for the working cylinder sleeves, form the following five sections (from top to bottom) isolated from each other:

(a) upper crankcase formed by the frame upper part and the upper covering bolted to lugs 14. Side walls 17 of this section have finished flanges 1 for the fuel injection pumps, and mounting pads 21 for the bearings of the pump rods. Two shelves 16 are welded to the inner surface of plates 17, and shelf 15 is welded to the outer surface to ensure higher longitudinal stiffness of the frame. Upper shelf 16 with the rib welded to it serves also as an oil catcher; the holes made in this shelf admit lubricating oil to the fuel injection pump tappets. The lateral plates of this section have holes for the upper oil feed pipe 12 and bores for the camshaft bearings. Transoms 9 are used for fixing the cylinders;

(b) scavenging air receiver 18 formed by the welded longitudinal bores and lateral partitions. The bores are provided with handholes closed with safety valves 2 (Fig.2), and with covers 3 (the latter having transparent eyes). Covers 3 and valves 2 alternate through every other section (Fig.1a). Valves 2 are also fitted on the stern end faces of the receivers. A hole with pipe union 4 (Fig.1c) to drain the oil out of the receiver is available in the frame stern part.

Brackets 6 (Fig.1a) hold the removable pads;

(c) section of injectors and starting valves.

The side plates of this section have large ports which ensure free access to the injectors and the starting valves on the working cylinder sleeves.

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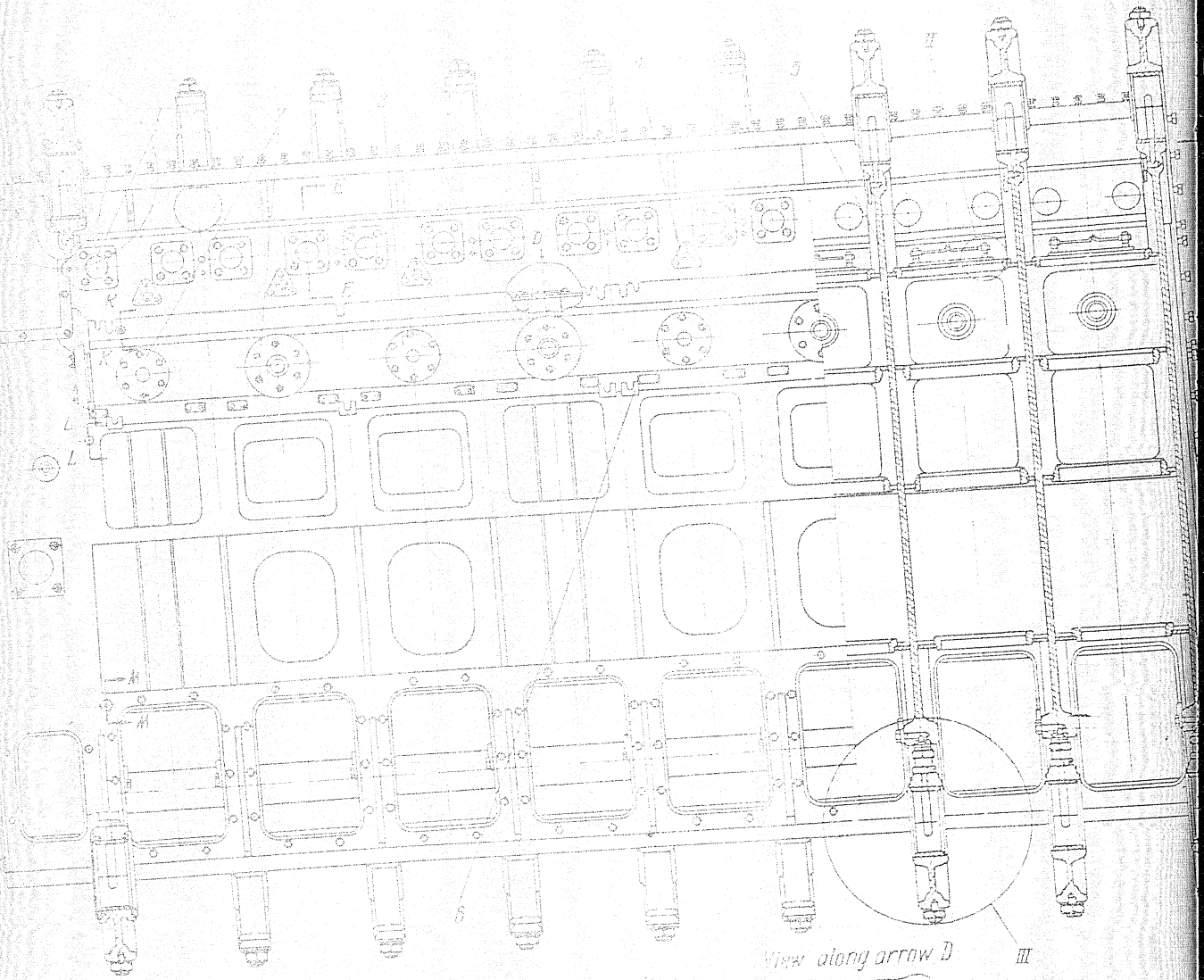
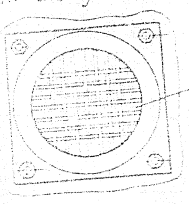


View along arrow D



Attachment of working cylinder sleeve to the frame

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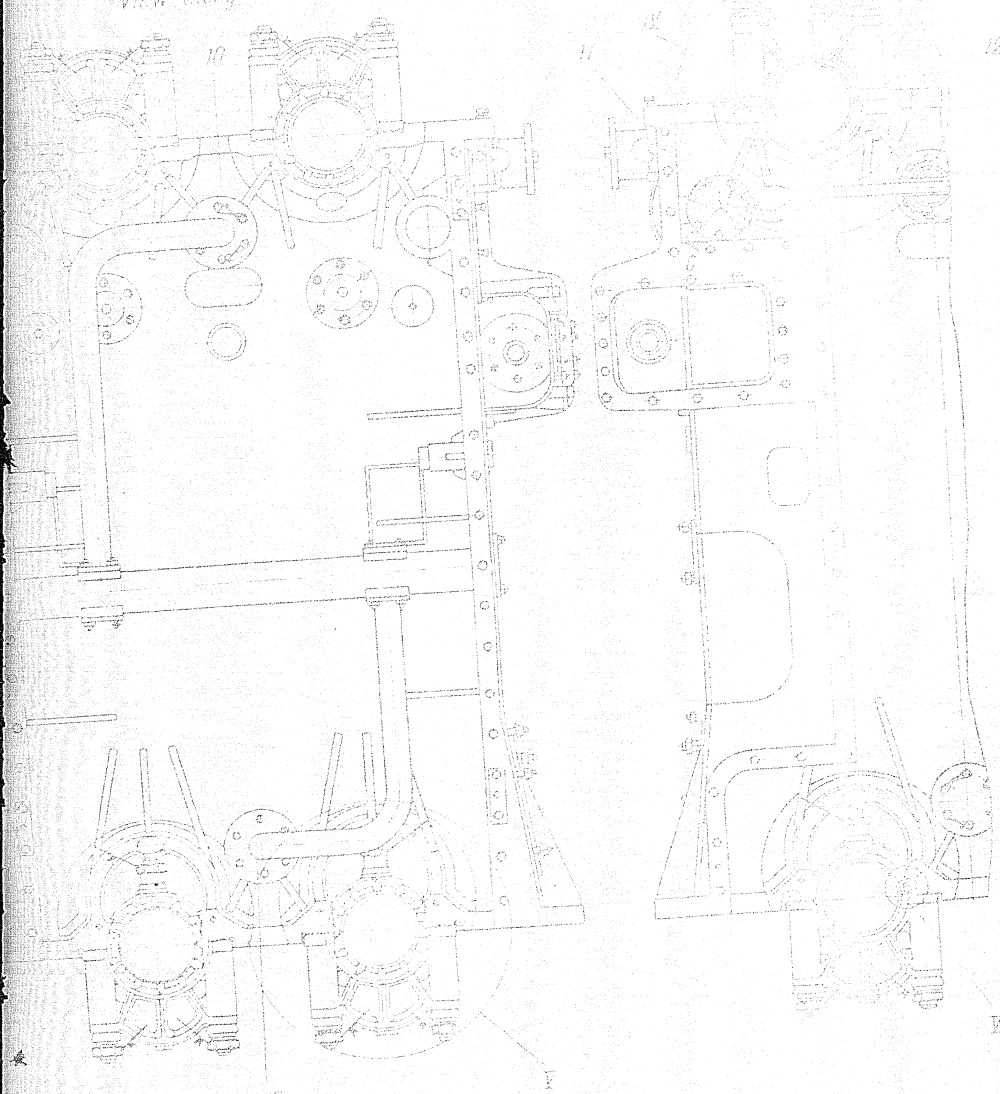
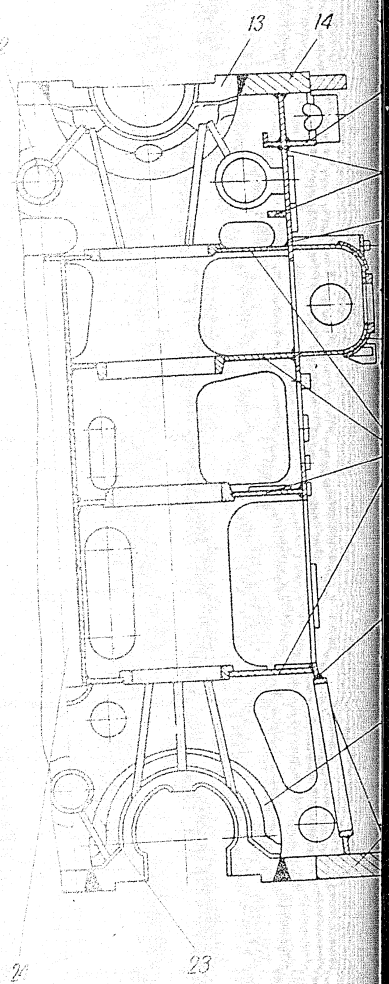
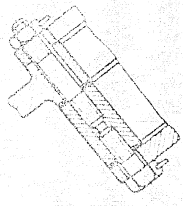
View along arrow A



Frame cross section



Section C C



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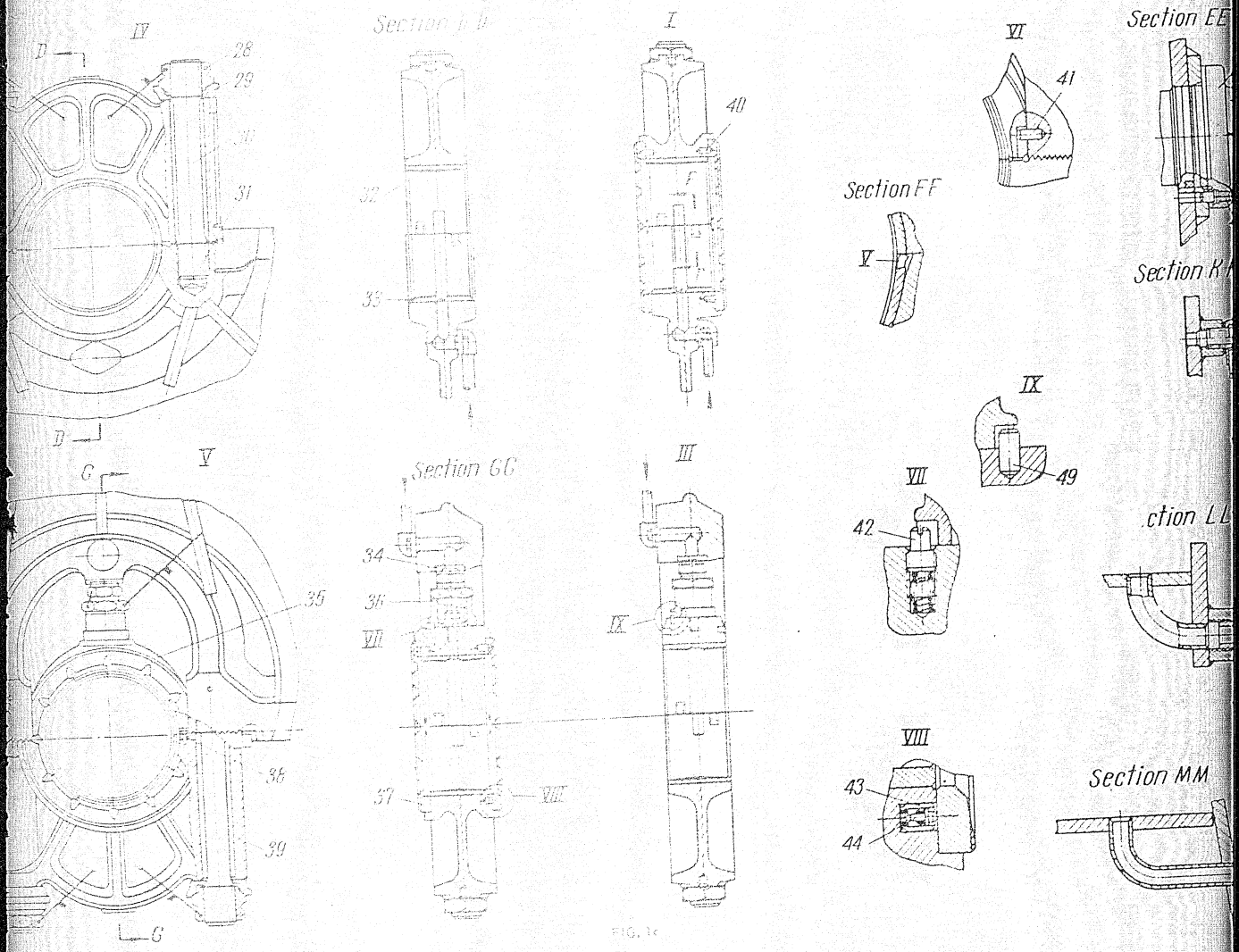

FIG. 1c

...SSEL ENGINE FRAME

...ion pipe; 24 – pipe; 25 – lower connecting pipe; 26 – pin; 27 – upper mount; 28 ...
...ll; 29 – conical washer; 30 – stud; 31 – wire; 32 – working half-bush; 33 – idle half-b...
...; 34 – thrust disc; 35 – bearing cap; 36 – jack; 37 – thrust half-ring; 38 – key; 39 – ...
...ing; 40 – thrust half-ring; 41 – pin; 42 – pin; 43 – bushing; 44 – retainer;
...; 46, 47, 48 – oil leakage drain pipe unions; 49 – pin; V – half-bush lock; A ...
injection pump

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(a) section of gas exhaust manifolds;

(b) bus section housing side plates;

(c) lower crankcase formed by the frame lower part, section ring bolted to lower lugs 22 (Fig.1b). Large openings closed by covers provided with explosion-proof valves (Fig.3) are available in side plates 20 (Fig.1b). The lateral plates of this section have holes for lower oil feed pipe 23.

The frame is divided into eight compartments by lateral vertical walls 5 (Figs 1a, 1b, 1c) which carry the main loads during engine operation. The lateral walls are made up of plates to which steel cast frames 13 and 21 are welded from top to bottom.

The engine frame stern compartment adjacent to the main drive is free of horizontal partitions. Stiffness of this compartment is ensured by oil feed pipe 8 welded into the side walls.

Hatches made in the upper and lower parts of the side walls and closed with blind covers allow to inspect the camshaft drive and the crankshaft couplings.

The main drive and the drive for major accessories are secured to respective flanges available at the frame end faces.

Upper frames 13 and upper mounts 27 form beds for the main bearings of upper crankshafts. Studs 30 and nuts 28 provided with spherical washers 29 attach upper mounts 27 to the frames.

The studs are held against rotation by wire 31 passed through drillings made in the frames.

Lower frames 21 are made in the form of arches which mount caps 35. These caps together with lower mounts 39 form beds for the main bearings of lower crankshafts.

Caps 35 are pressed to the lower mounts by jacks 36 whose hardened spherical bolt rests against spherical thrust disc 34 pressed into lower frame 21. The jack bolt is secured by a locknut tied to the bolt and frame by means of wire, so as to prevent self-unscrewing of the nut.

The stern main bearings (on the side of the main drive), both upper and lower, are locating ones. The bodies of the locating bearing jacks are held by threaded pins 42, while those of the other bearings are secured by pins 49.

All the mounts (except the stern ones) and all the caps are kept against longitudinal travel by pins 26 and 41, respectively, which at the same time prevent wrong installation of the mounts and caps during assembly and overhauls.

Longitudinal splines made on the bearing surfaces of the mounts and on the respective mating surfaces of the upper and lower frames prevent travel of the mounts with regard to the frames.

The stern main bearings (on the side of the main drive), both upper and lower, are locating ones.

Collars made on stern mounts 39 and caps 35, as well as in the upper stern frames, form end face seats which receive two steel half-rings 37 with a babbit-lined working surface. The babbit layer is provided with recesses to produce an oil wedge.

Upper half-rings 37 are secured by pins 41.

Spring-loaded retainers 44 housed inside bushings 43 press the half-rings constantly to the crankshafts.

Longitudinal travel of stern mounts 39 is prevented by bosses which are welded to the mounts and get into special grooves made in the frames.

Keys 38 screwed to the mounts secure caps 35 with regard to lower mounts 39.

Each main bearing comprises two steel half-bushes lined with lead bronze.

The inner surface of idle half-bush 33 has a circular groove with an oil feed hole.

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Working half-bushes 32 are fitted in the mounts of the upper and lower crankshafts. Idle half-bushes 33 of the upper crankshafts are mounted in the frame beds, while those of the lower crankshafts are fitted in caps 35.

All the half-bushes are held in position by means of locks V entering the slots of the respective beds, and are fitted into the beds with a negative allowance (the total stretched length of both half-bushes is larger than the bed circumference).

Oil is fed to the main bearings along two pipelines, namely upper oil feed pipe 12 and lower oil feed pipe 23. These pipelines communicate with lateral oil feed pipe 8 through pipes 10 and 25. The upper and lower frames are provided with finished flanges which attach the pipes branched-off from pipelines 12 and 23. These pipes supply oil to the bushes of the upper crankshaft bearings (through angular passages drilled in the frames) and to the bushes of the lower crankshafts (through passages drilled in jacks 36 and in caps 35).

The camshafts are lubricated with oil supplied through boxes 11 attached to the frame bow wall.

Three pipes 24 provided with screens 7 on top ensure overflow of oil from the upper crankcase into the lower one.

Ports made in lateral walls 5 provide for overflow of oil lengthwise the frame.

The oil leaking from the frame outer shelves is drained out through holes which receive pipe unions 46 and 48 provided with return pipes.

AIR RECEIVER SAFETY VALVE

The disc of valve 5 (Fig.2) provided with a transparent eye is pressed to base 7 by springs 2 and 6.

The required compression of the spring is ensured by stops 3 fitted on studs 8.

Rubber ring 4 seals the disc of valve 5. The valve is covered by casing 1 on top.

COVERINGS OF LOWER CRANKCASE HATCHES

The lower crankcase hatches are closed by covers provided with safety valves (Fig.3). The cover of the end stern hatch has no safety valve. The harch covers are sealed by rubber gaskets.

The safety valves serve at the same time as quick-removable covers for inspecting the moving parts. All parts of the valve are assembled on stem 8, with cover 2 pressed to its collar. Screwed on stem 8 is sleeve 10 provided with a thrust washer loaded by spring 9. Valve cover 2 is pressed to the hatch cover by spring 9 and is sealed by rubber ring 1. Lugs 7 serve for attaching the valve to the hatch cover. The cover is removed with the aid of handwheel 3. Leakage of oil along the stem is prevented by seal 6 provided with pressure plunger 5.

UPPER COVERING

The welded upper covering provided with inner ribs is bolted to the frame. The joint between the covering and the frame is sealed by gasket 10 (Fig.4) made of oil-resistant rubber, whereas the joint between the covering and the main drive is sealed by a paronite gasket.

One handhole closed by inspection cover 2 provided with a safety valve (see Fig.3) is made in the covering per each two adjacent working cylinders.

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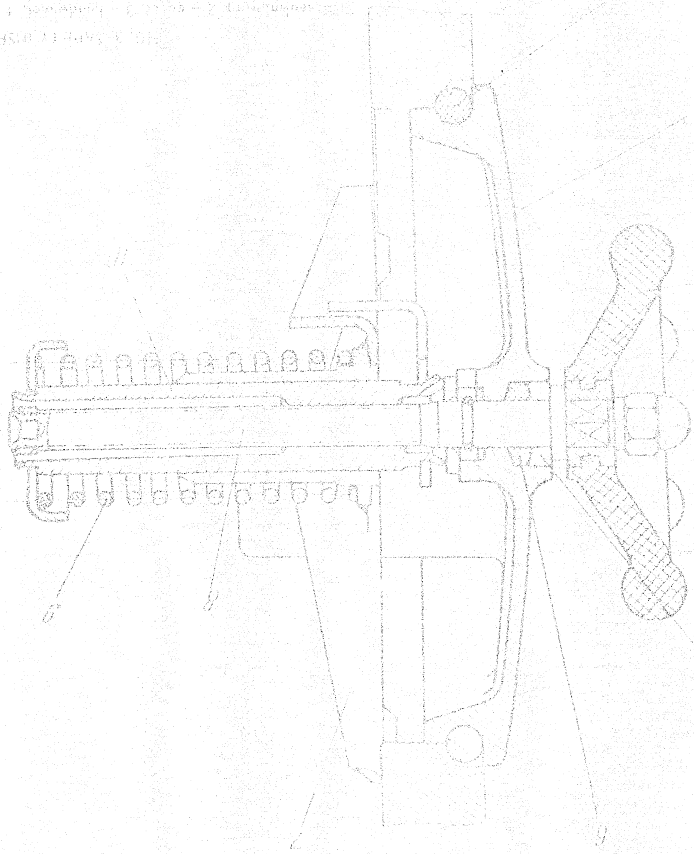

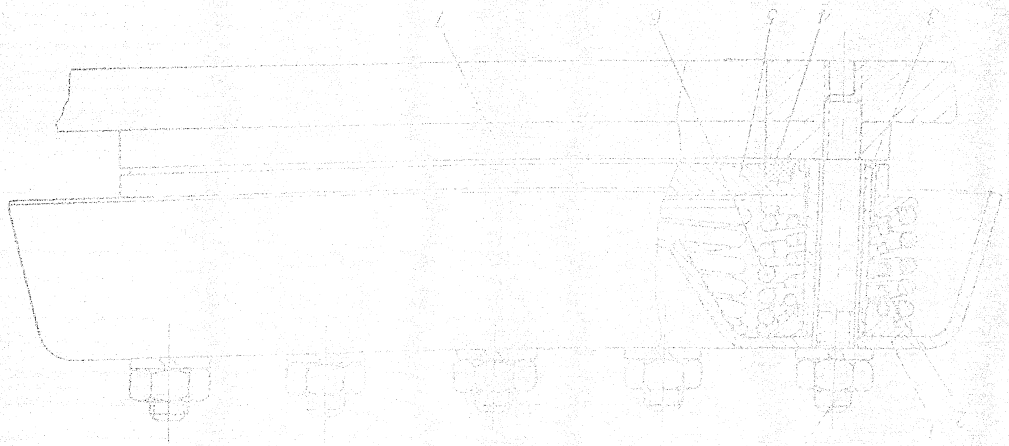

STAT

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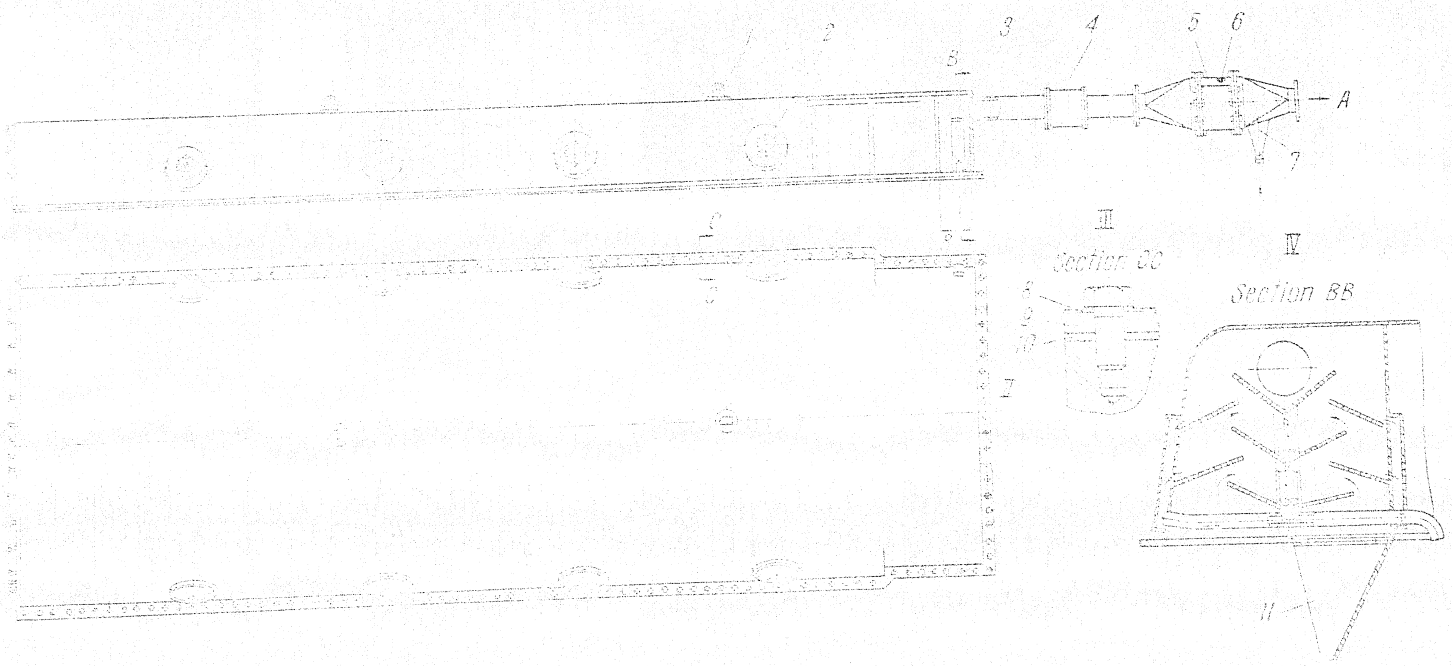

FIG. 4. UPPER COVERING

1 — overlay; 2 — intercooler cover with ribbed covering; 3 — cover; 4 — [illegible]; 5 — compensator; 6 — cover; 7 — [illegible]; 8 — [illegible] place; 9 — covering; 10 — [illegible]; 11 — [illegible]; A — [illegible] to cylinder; B — [illegible] to [illegible]; C — [illegible]; D — [illegible]; E — [illegible]; F — [illegible]; G — [illegible]; H — [illegible]; I — [illegible]; J — [illegible]; K — [illegible]; L — [illegible]; M — [illegible]; N — [illegible]; O — [illegible]; P — [illegible]; Q — [illegible]; R — [illegible]; S — [illegible]; T — [illegible]; U — [illegible]; V — [illegible]; W — [illegible]; X — [illegible]; Y — [illegible]; Z — [illegible]; a — [illegible]; b — [illegible]; c — [illegible]; d — [illegible]; e — [illegible]; f — [illegible]; g — [illegible]; h — [illegible]; i — [illegible]; j — [illegible]; k — [illegible]; l — [illegible]; m — [illegible]; n — [illegible]; o — [illegible]; p — [illegible]; q — [illegible]; r — [illegible]; s — [illegible]; t — [illegible]; 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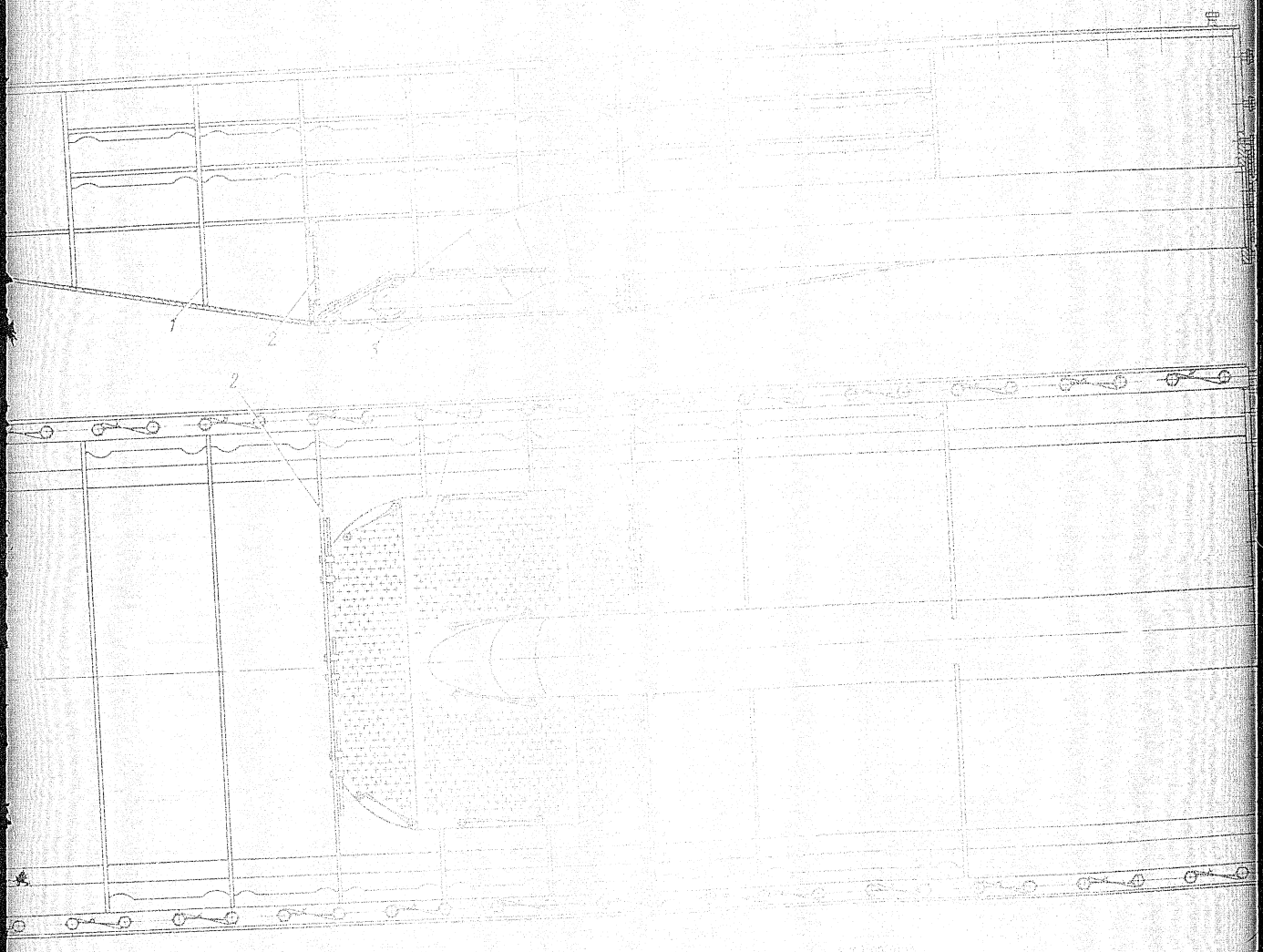

1 – lateral tube 2 – Mar

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Attached to the covering end flanges is a pipe which has compensator 4 (Fig.4) and connects the crankcase to the turbo-supercharger suction cavity, due to which it is possible to maintain rarefaction in the crankcase during operation of the diesel engine. The necessary value of rarefaction is insured with the aid of throttling washer 8.

Oil separator 5 filled with wire (metal wool) 6 is fastened to the pipe. Oil particles are drained from the separator along branch pipe 7 into the engine sump (see Fig.29) through the pipe hydraulic seal.

Besides, throw of oil from the crankcase into the turbo supercharger suction cavity is lessened by an oil catcher (see section through B-B) and oil slinger 11 mounted inside the upper covering.

Eye-bolts 1 are used for lifting the upper covering.

OIL SUMP

The welded sump serves as diesel engine oil collector.

The joints between the oil sump and the frame, the main drive and the drive for major accessories are sealed by paronite paskets. Lateral and longitudinal ribs provide the necessary stiffness to the sump. The central (deepest) part of the sump is closed on top with perforated plates 4 (Fig.5) which prevent agitation of oil and formation of air-oil emulsion. Oil suction pipe 6 connects the oil pump scavenging section to the lowest point of the oil sump.

Ports closed by flap valves 2 and 5 available in the vertical walls of the sump middle part serve to prevent overflow of oil from the middle part during inclination of the diesel engine.

The valves open only towards the inside of the sump middle part and maintain the oil level above the edge of pipe 6.

The pipeline running from the independent oil pump is attached to one of side flanges 3.

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Chapter III

CRANK GEAR

CRANKSHAFT

The diesel engine crankshafts (Figs 6a, 6b) made of alloy steel are similar in design and differ only in the location of cranks and furnishing of the stern and bow ends. The cranks of all the crankshafts are set around the circumference at an angle of 45^{O}. Both the upper and lower crankshafts have a similar arrangement of respective cranks.

The ninth main journal (if counted from the bow end) is a thrust one, limiting the shaft axial travel.

All crankpins and main journals are provided with longitudinal drillings. The crankpin holes are closed with stamped plugs 6, while the holes in the main journals are closed with steel taper covers 4 tightened up by studs 15. Each crankpin and journal is provided with two holes C, and each web has one hole B, to ensure overflow of oil.

Dampers 14 are attached to the bow flanges of all the crankshafts. As the dampers are misaligned from each other in axial direction, the shaft bow flanges carry either intermediate disc 12, or adapter sleeve 10 or splined coupling 11 both provided with flanges for fastening the dampers. Splined coupling 11 is mounted on the portside lower crankshaft.

Splined coupling 11 houses splined bushing 9 held against axial travel by disc 8 and ring 14. This splined bushing is engaged with torsion shaft 16 (Fig.13b) which connects the crankshaft to the drive for major accessories.

Splined couplings 2 (Figs 6a, 6b) fitted with toothed rims to drive the camshafts are secured to the stern flanges of upper crankshafts, while splined couplings 3 are attached to the stern flanges of the lower crankshafts. Splined couplings 2 and 3 receive the main drive intermediate shafts (see Fig.11a).

Balance weights 1 (Fig.6a) are fastened to the stern couplings of all the crankshafts, while balance weights 7 are attached to all dampers.

To ensure lubrication of the splines, the 9th main journal carries a bolt with two holes in the nipple; for the same purpose, the 1st main journal has a bolt provided with an inclined hole, and a plug with three splines. The arrangement of crankshafts in the diesel engine is shown in Fig.7.

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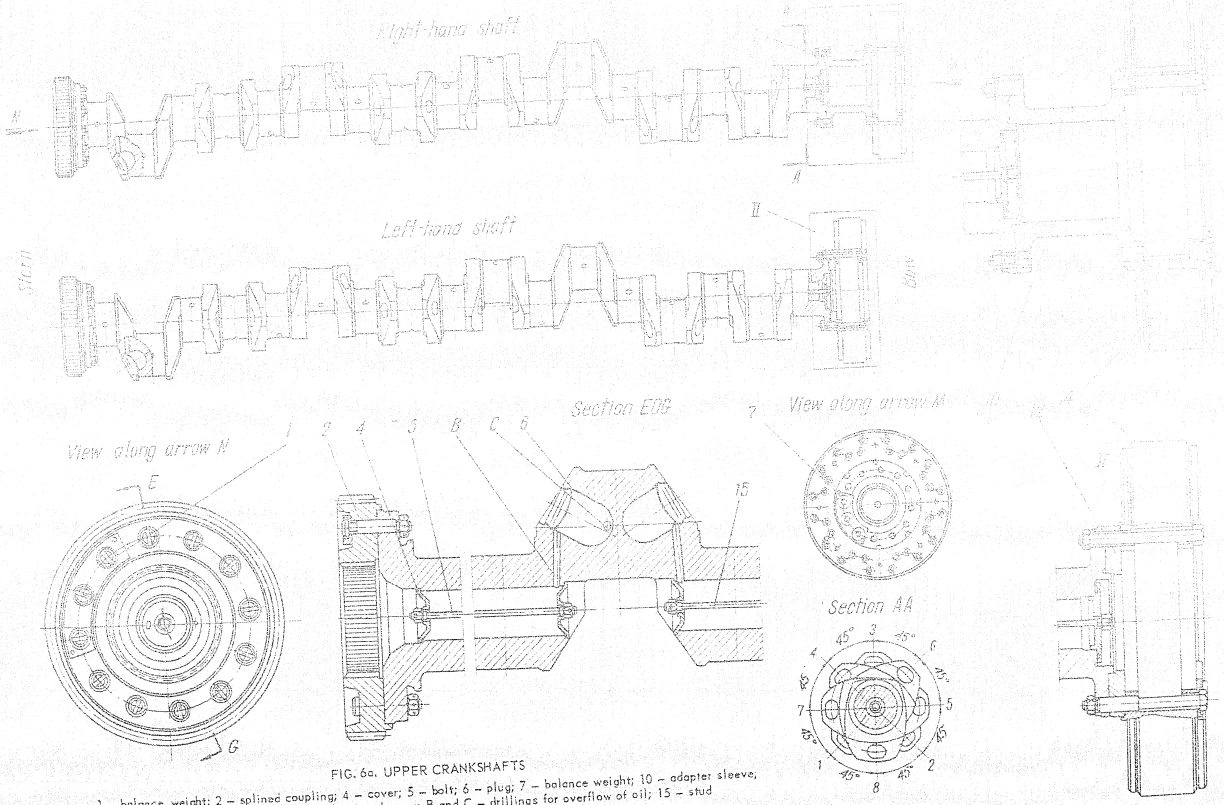

FIG. 6a. UPPER CRANKSHAFTS

1 – balance weight; 2 – splined coupling; 4 – cover; 5 – bolt; 6 – plug; 7 – balance weight; 10 – adapter sleeve; 12 – intermediate disc; 14 – torsional vibration damper; B and C – drillings for overflow of oil; 15 – stud

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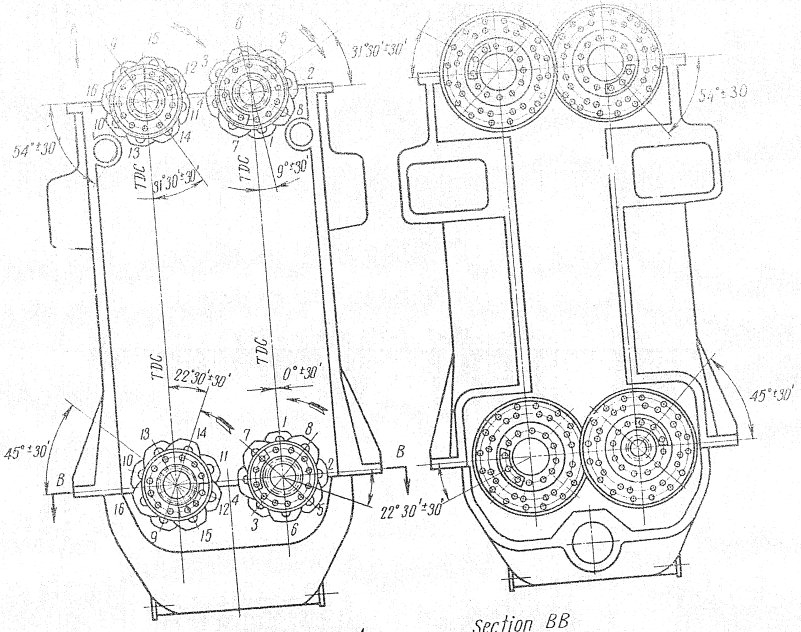
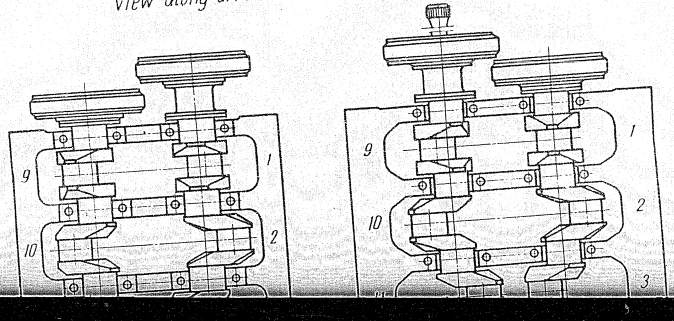


View along arrow A

Section BB



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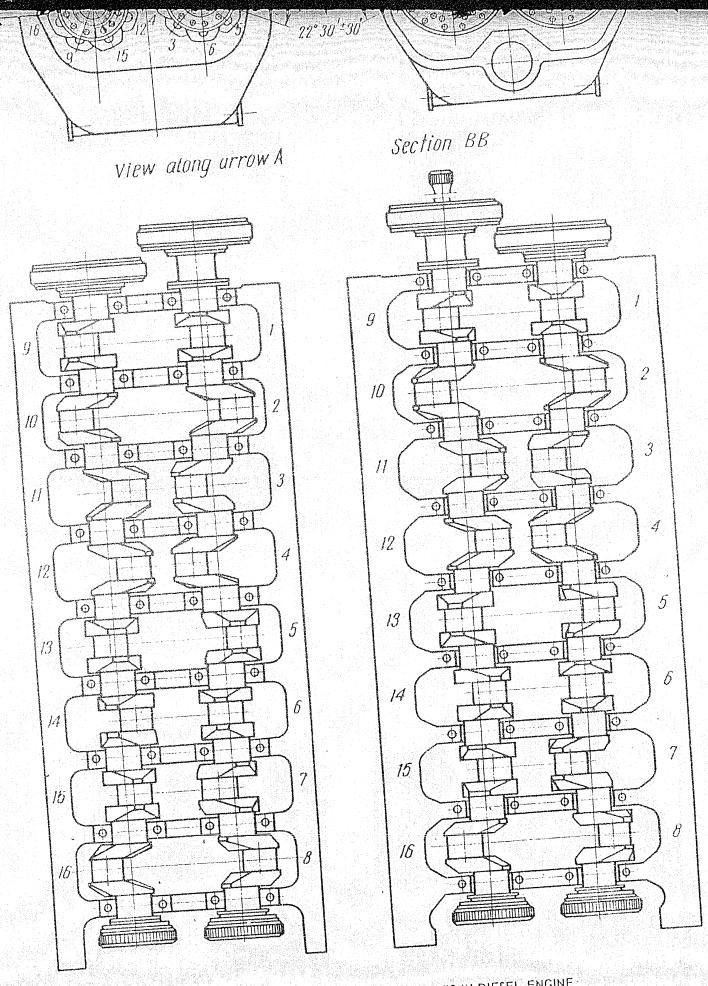

FIG. 7. ARRANGEMENT OF CRANKSHAFTS IN DIESEL ENGINE
I – view from engine stern side; II – view from engine bow side

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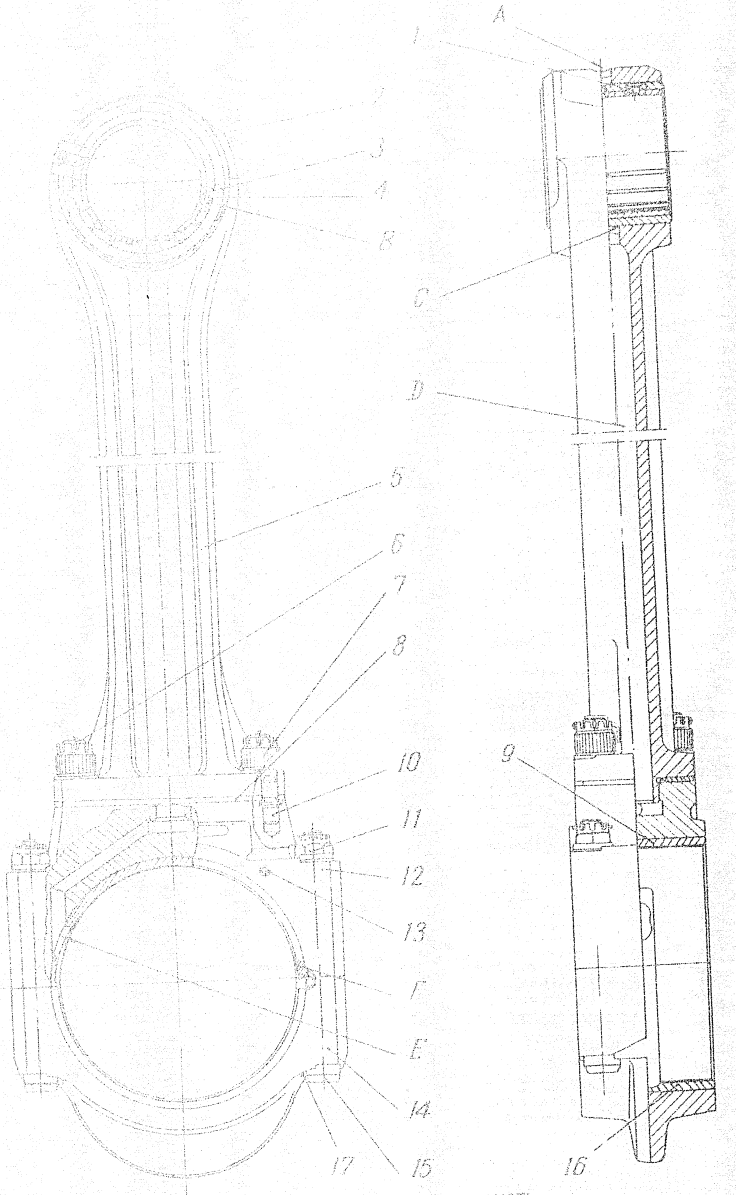

FIG. 8. CONNECTING ROD (EXHAUST)

1 – pin; 2 – pin; 3 – inner bushing; 4 – shell; 5 – connecting rod blade; 6 – stud; 7 – nut; 8 – compression shim; 9 – half-bush; 10 – pin; 11 – nut; 12 – big end; 13 – pin; 14 – big end cap; 15 – connecting rod bolt; 16 – half-bush; 17 – pin; A – oil hole; B – radial hole; C – circular groove; D – connecting rod blade oil passage; E – oil hole; F – half-bush lock

end bearing sectional bushing made up of outer steel tube 4 and inner bronze bushing 3 interconnected by two pins 1 and 2. The inner surface of bushing 3 is provided with

piston pin. The end

bearing bushing is locked by pin 2.

Big end 12 is fastened to the connecting rod blade by four studs 6 and has four holes for connecting rod bolts 15. Pin 10 secures the end with regard to the connecting rod blade. Studs 6 are held by nuts 7. Split nuts 7 and 11 are locked by cotter pins. Compression shim 8 is placed between the big end and the connecting rod blade to adjust the compression ratio.

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Bronze half-bushes 9 and 16 are lined with a thin layer of antifriction alloy. The half-bushes are held in place by locks F. Connecting rod cap half-bush 16 has a wide circular groove in its middle part, while half-bush 9 is provided with short grooves and holes E for oil.

The crankpin bearing bush is lubricated with oil running along the crankshaft passages. Along drilled passage D, oil is fed to lubricate the end bearing (through circular groove C) and to cool the piston (via hole A).

PISTON

The upper (scavenging) and lower (exhaust) pistons are similar in design and differ only in the quantity of protective and oil-control rings.

The piston comprises two main parts: trunk 1 (Fig.9) cast of high-strength iron, and steel insert 13.

The trunk head spherical concave surface with recesses admitting the fuel into the combustion chamber and the cylindrical surface at a distance of 30 mm from the head are chrome-plated. To ensure better running-in, the trunk outer side surface is coated with a thin layer of tin. A groove (expansion clearance) is cut in the trunk between the second and third piston ring grooves.

Four compression rings are inserted into the grooves of the trunk upper part. Top ring 2 is chrome-faced. On its inner surface the ring carries lug G which enters a special slot cut in the trunk groove and thus locks the ring in the groove so that during the travel of the piston the ring joint is against the widened lands of the scavenging and exhaust ports of the working cylinder sleeve. Rings 3 are provided with a bronze collar on the working surface.

The three grooves made in the trunk lower part receive two protective rings 9 and two oil-control rings 10 (in one groove) turned with their oil-control edges towards each-other. All the compression rings are of the bevel-joint type, whereas the protective and oil-control rings are of the straight-joint type. The rings are made of high-strength cast iron.

The working surfaces of compression rings 2 and 3 and protective rings 9 are also coated with a thin layer of tin, to provide for better running-in. The inner surface of the oil-control rings carries lug F which gets into the respective cut of the trunk and holds the ring in a definite position. The oil scraped by the oil-control rings off the sleeve face is drained out through drillings A available in the trunk.

Insert 13 is held to the trunk by four studs 4. The position of the insert in the trunk is determined by the insert centring collars and by pin 12.

Hollow piston pin 7 made of alloy steel is inserted into the holes of the insert bosses. Rotation and axial travel of the pin are prevented by insert-holding studs 4.

The piston is cooled with oil delivered into insert cavity E from the connecting rod small end via slipper 6 pressed tightly to the connecting rod end by spring 5. The oil gets from cavity E into cavity C, cools the piston head and the zone of compression rings, then it flows through bottom grooves B and insert drilling D into the cavity formed between the insert and trunk, whence it is discharged along drain pipe 8.

Drain pipe 8 and blank plug 11 are fitted on studs 4 and are fastened together with the insert by means of nuts 14. Cotter pin 16 secures nuts 14 with regard to studs 4, while tab washers 15 lock the nuts relative to blank plug 11.

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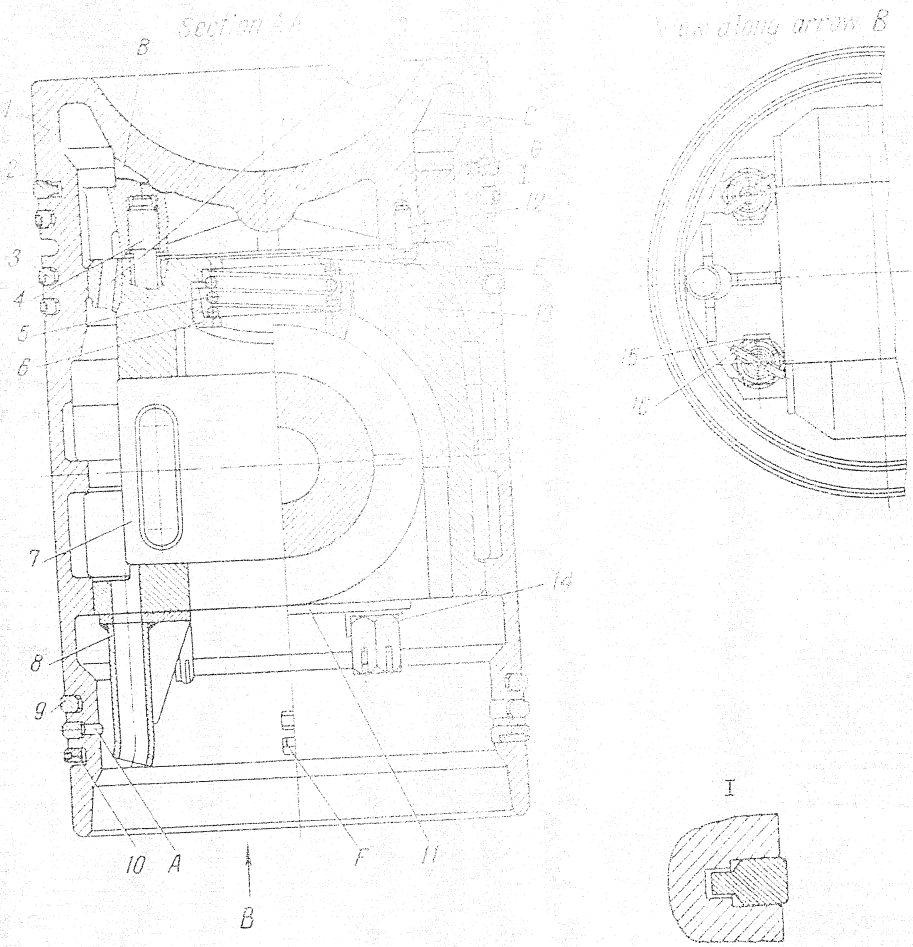

FIG. 9. PISTON

1 – trunk; 2 – compression ring (chrome-faced); 3 – compression rings; 4 – stud; 5 – spring; 6 – slipper; 7 – pin; 8 – drain pipe; 9 – protective ring; 10 – oil-control ring; 11 – blank plug; 12 – pin; 13 – insert; 14 – nut; 15 – tab washer; 16 – cotter pin; A – oil drain drilling; B – trunk groove; C – cooling cavity; D – oil supply drilling; E – oil cavity; F – oil-control ring lug

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TORSIONAL VIBRATION DAMPER

Damper steel hub 7 (Fig. 10) is attached to the crankshaft by means of gauged bolts. Loose-fitted on the hub is damper steel rim 10. Both the damper hub and rim have eight seats, with two spring packs 4 and one pin 3 fitted into each seat. Bronze shoes 1 are caulked into the hub projecting parts, and aluminium rings 6 are caulked into the hub end faces.

The spring packs comprise a set of circular plate springs inserted one into the other. Travel of the rim over the hub circumference is prevented by pins 3 fitted into the holes of the spring packs.

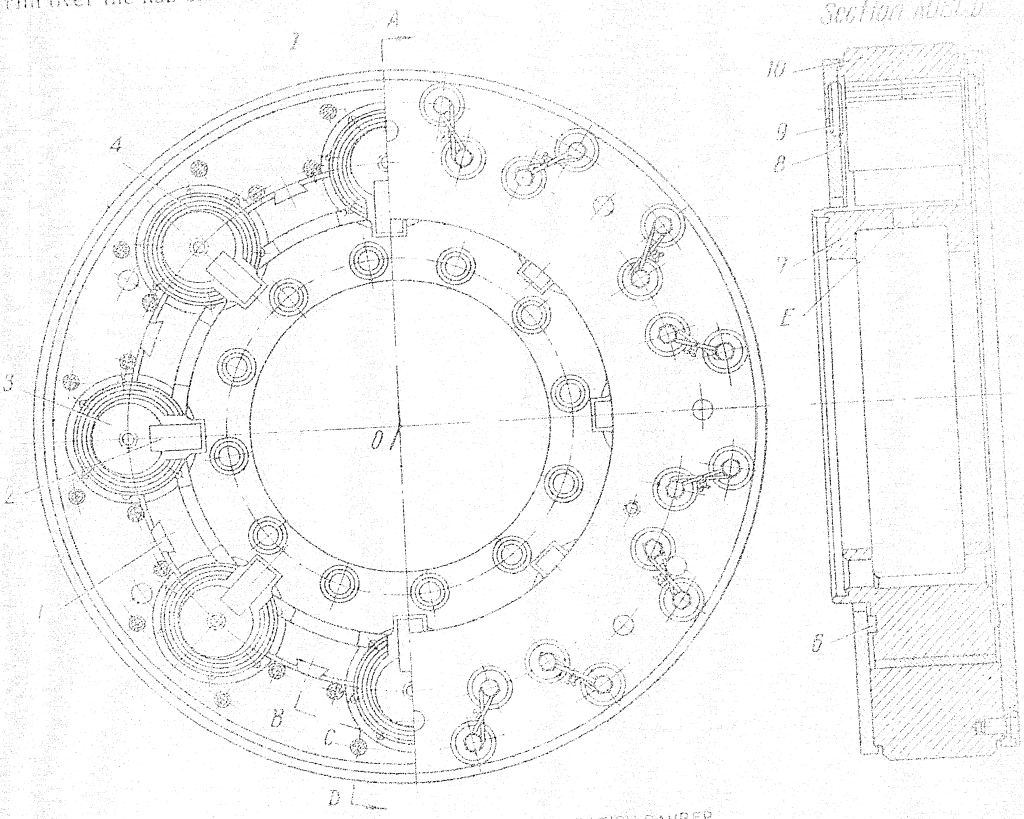

FIG. 10. TORSIONAL VIBRATION DAMPER

A – view with disc removed; 1 – bronze shoe; 2 – pin key; 3 – pin; 4 – spring pack; 5 – disc; 6 – aluminium ring; 7 – hub; 8 – disc; 9 – stop; 10 – rim; E – oil hole

Keys 2 welded to the pins hold the spring packs against rotation in the seat. Both end faces of the rim carry discs 5 and 8 which cover the seats with the springs and prevent axial travel of the rim along the hub.

Case-hardened stops 9 which prevent wearing of the discs due to friction against the spring ends are pressed into the discs, opposite the seats.

The damper is lubricated with oil rutning from the crankshaft. Oil is delivered along hub holes E to lubricate the spring packs, the pins and shoes (not shown).

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The diesel engine gear train forms the following reduction gears:

1. Main drive;
2. Major accessories drive;
3. Minor accessories drive;
4. Camshaft drive.

Each of the first three reduction gears is assembled in its own housing with all mechanisms and is connected with the engine frame by means of studs. The camshaft drive has no housing of its own and is assembled finally during installation on the engine.

MAIN DRIVE

The main drive comprises four driving gears 1 (Figs 11a, 11b) and two welded gears 3 and 5 enclosed in a welded housing. The gears are of the herringbone type. The main drive assembly is attached to the stern end face of diesel engine frame.

The main drive is designed to:

(a) combine and transmit the power from the four crankshafts to the power take-off shaft;

(b) ensure constant valve timing among the rows of working cylinders;

(c) reduce the speed of the power take-off flange relative to the speed of the crankshafts.

The diesel engine crankshafts and main drive driving gears 1 co-axial with them are interconnected by hollow intermediate (torsion) shafts 8.

Both ends of the intermediate shafts carry splined rims with different number of teeth: the rims with the smaller number of teeth come into mesh with the crankshaft splined couplings (see Figs 6a and 6b), while the splined rims with the larger number of teeth are engaged with the splines of driving gears 1 (Figs 11a, 11b).

The splined rims provided with different number of teeth ensure proper mutual location of the shafts (in compliance with Fig. 12) during diesel engine assembly.

All gears 1 (Figs 11a, 11b) are similar in design and differ only in the direction of the helix which is opposite for the upper and lower gears.

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Flanges 30 limiting the travel of shafts 6 are fastened to the stern end faces of three gears 1, while the fuel feed pump drive is attached to the end face of the fourth one. This drive includes shaft 36 keyed in shaped flange 30 of half-coupling 29 with cams, a joint-coupling, and retainer 28. Seal 27 prevents entrance of fuel into oil.

The torque from two upper gears 1 is transmitted to intermediate gear 5 meshed with gear 3 which carries power take-off flange 4. The torque of two lower gears 1 is transmitted directly to gear 3.

Gears 3 and 5 consist of a rim, steel discs and a hub, all interconnected by welding. Welded oil thrower ring 51 is fitted on power take-off flange 4.

Flange 4 carries shaft barring arrangement worm gear rim 2 secured by bevel bolts 38 and nuts 39.

The main drive housing is made up of three welded boxes 12, 13 and 15 installed one on the other, so that their joint faces are in line with the axes of gears 5 and 3. All the boxes of the housing are braced together into a common rigid construction by means of eight long studs 55 passing through pipes welded into the housing walls. At the same time, studs 55 tighten up the bearing beds. In addition to the studs, all the boxes are interconnected by short bolts along the perimeter. Sealing of the joints between the boxes is ensured by special sealing compound "Hermetic". To center the housing boxes with each other, each joint face is provided with four gauged bolts.

Besides the steel pipes, forged bearing beds are also welded into the housing boxes.

Pads 22 and bosses 45 for mounting the shaft barring arrangement are welded to the stern end face walls of boxes 13 and 15 and to the side wall of box 13.

Boxes 13 and 15 have two, and box 12 has three inspection holes closed by covers 18 provided with the same safety valves as used in the side coverings of the lower crankcase (see Fig.3).

Welded to the side wall of box 13 (Figs 11a, 11b) are pads 44 for mounting the emergency control station. Stops 16 used to secure the end face shock absorbers are welded to the stern end face wall of box 15. Angle brackets for lifting the main drive are welded to the box upper wall.

Steel bushings 35 babbit-lined over the working surface serve as supporting bearings for gears 1. The bushings are fitted into the drive housing bores and bolted to the housing flanges.

Each supporting bearing of gears 3 and 5 consists of two thin-walled steel half-bushes 47 lined with babbit. To improve the operating conditions, the joint faces of the half-bushes are turned through 90° relative to the joint faces of the boxes, since the main forces of the gears are directed along the joint face of the housings. Half-bushes 47 are locked by pins 48.

The main drive locating bearing comprises flanges 6 and 10 attached to the end faces of gear 5, and bronze ring 41 pressed by ring 42 to the flanges available at the end faces of the beds intended for the bearings of gear 5. Centering of the gears in axial direction with regard to the drive housing, and adjustment of the axial clearance in the locating bearing are done by varying the thickness of rings 40.

Lubricating oil for the main drive is fed from the diesel engine frame into pipe 14, whence it is directed along pipes 21, 20 and 19 to lubricate the stern bearings. Pipes 46 and 49 supply oil to the drive bow end, while pipes 23, 24 and 25 direct the oil to the bow bearings. Gears 5 and 3 are lubricated with oil flowing out of the holes made in pipes 49. To clean these pipes, pipe 14 has bosses with holes closed by plugs 50.

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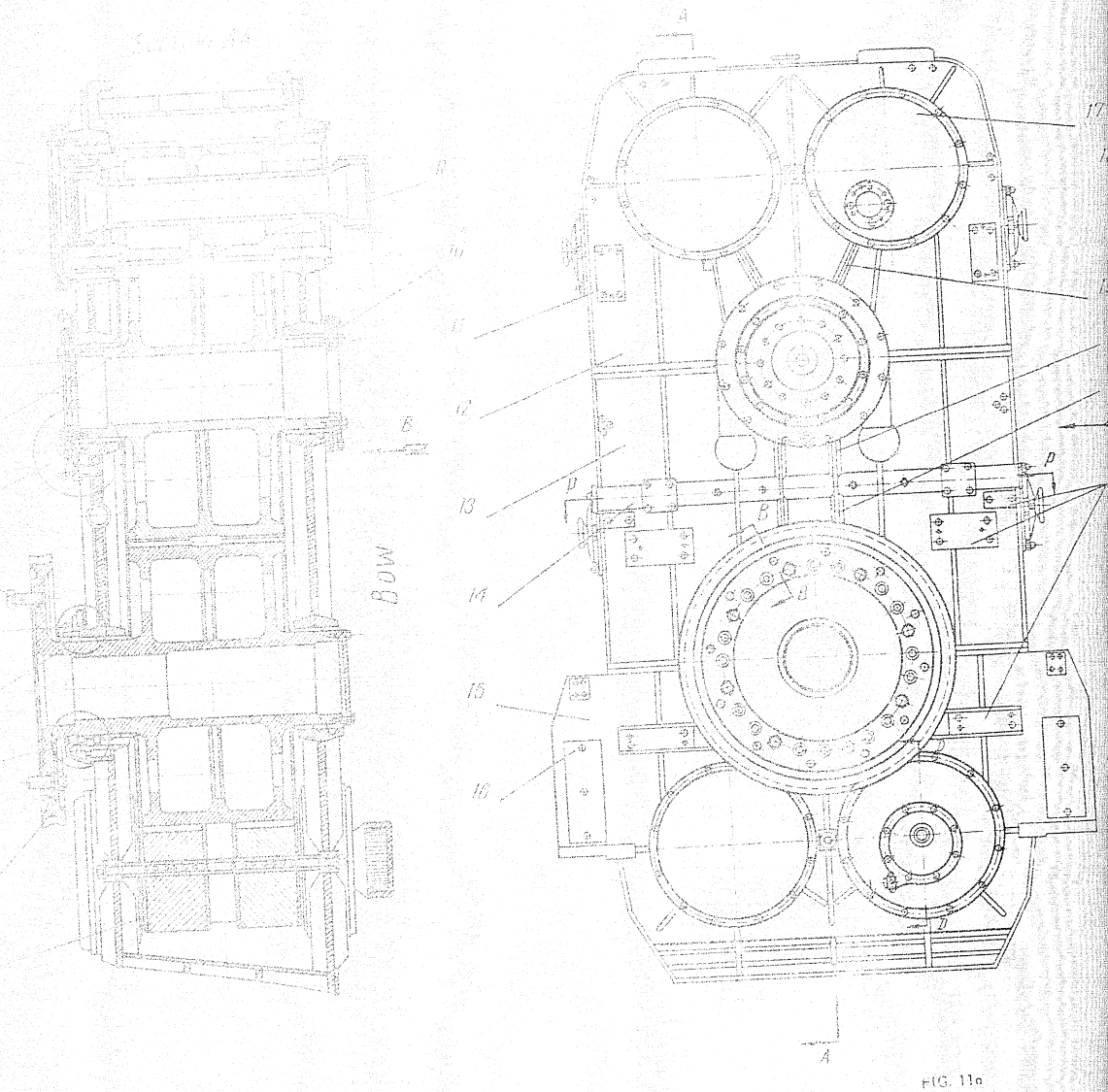

FIG. 11a

FIGS 11a - 11d. MAIN DRIVE

1 – driving gear; 2 – shaft bearing arrangement (four only); 3 – intermediate gear with power take-off flange; 4 – power takeoff flange; 5 – intermediate gear; 6 – minor accessories drive flange; 7 – cap; 8 – tachometer (frontal) shaft; 9 – oil hole; 10 – flange; 11 – flat for fastening the bearings of fuel pump; 12 – frontal central shaft; 13 – housing upper lock; 14 – housing intermediate box; 15 – lateral pipe; 16 – housing lower box; 17 – stay; 18 – cap; 19 – cover with explosion-proof valve; 20 – pipe; 21 – pipe; 22 – nut for mounting the shaft bearing arrangement; 23 – nipple; 24 – elbow; 25 – pipe; 26 – cover; 27 – seal; 28 – 33 – circular groove; 34 – 37 – oil holes; 38 – taper 44 – pad for mounting the 49 – pipe; 50 – plug; 51 –

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View along arrow B

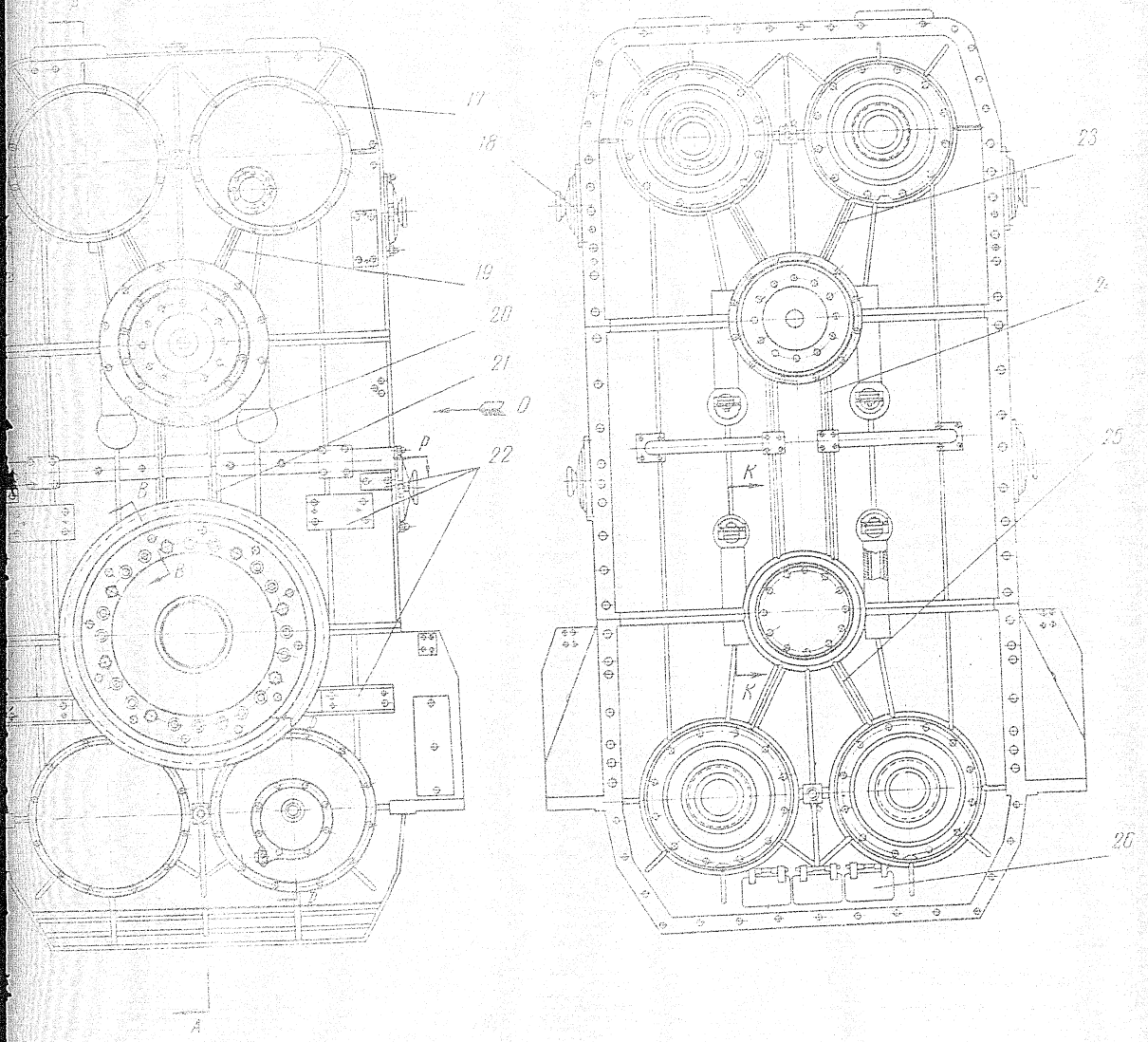

FIG. 11a

FIGS. 11– 13. MAIN BODY B

26 – cover; 27 – seal; 28 – retainer; 29 – half-coupling; 30 – flange; 31 – cap; 32 – oil note;
33 – circular groove; 34 – oil hole; 35 – bushing of supporting bearing; 36 – fuel feed pump drive shaft;
37 – oil holes; 38 – taper bolt; 39 – nut; 40 – ring; 41 – bronze ring; 42 – ring; 43 – oil passage;
44 – pad for mounting the emergency control station; 45 – boss; 46 – pipe; 47 – half-bush; 48 – pin;
49 – pipe; 50 – plug; 51 – oil control ring; 52 – oil catcher; 53 – flange; 54 – oil hole; 55 – stud

...gear with power take-off;
...ductive flange; 7 – cap;
...fastening the bearings of fuel pump;
...ket; 14 – lateral cover;
...ntrol valve; 19 – pipe; 20 – pipe;
...24 – hose; 25 – pipe;

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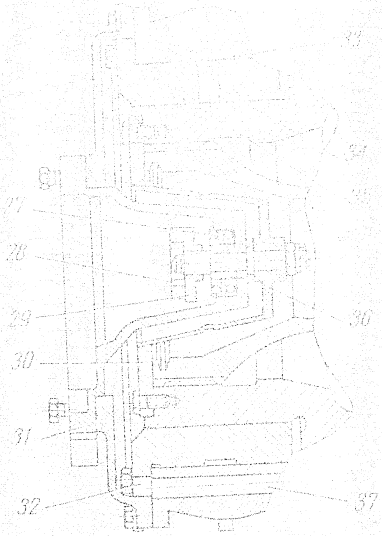

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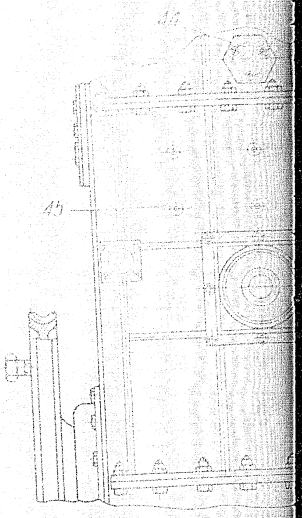

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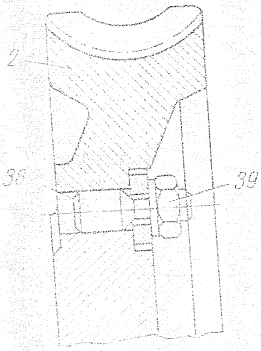

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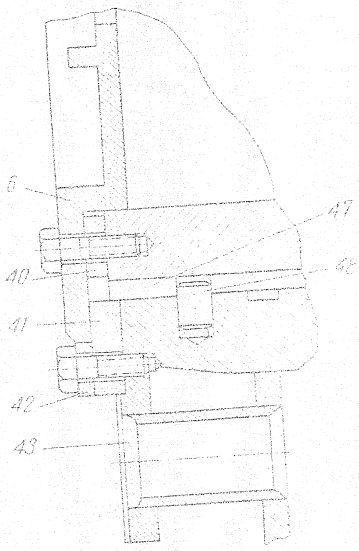

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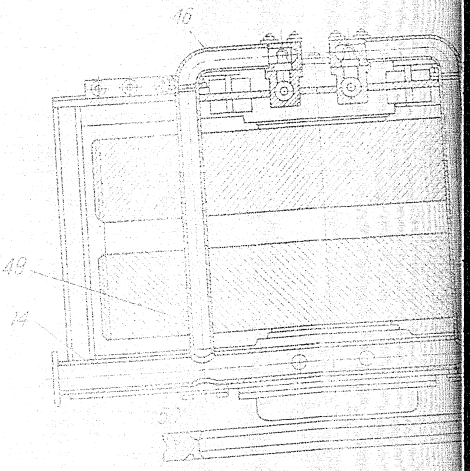

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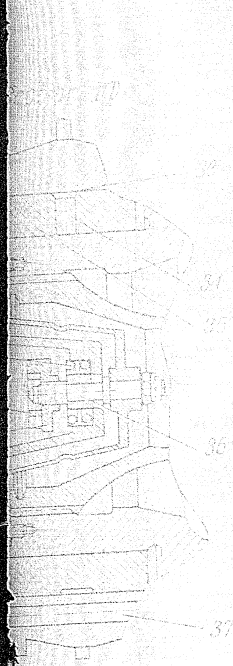

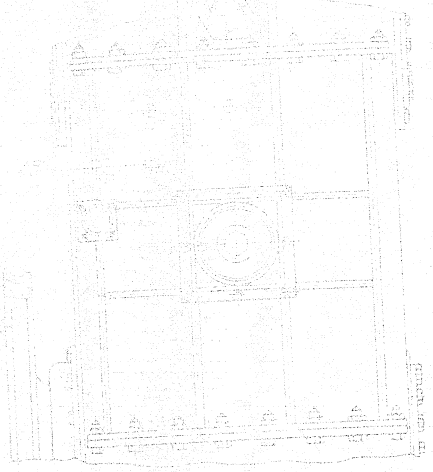

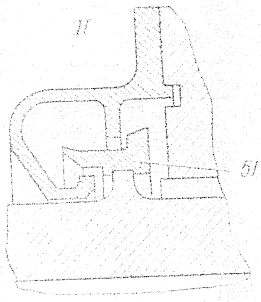

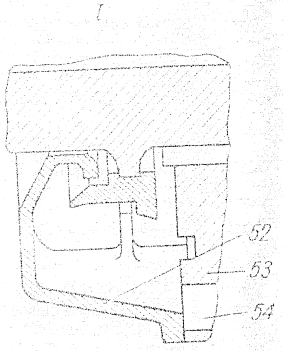

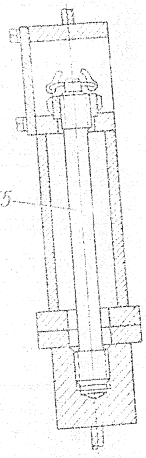

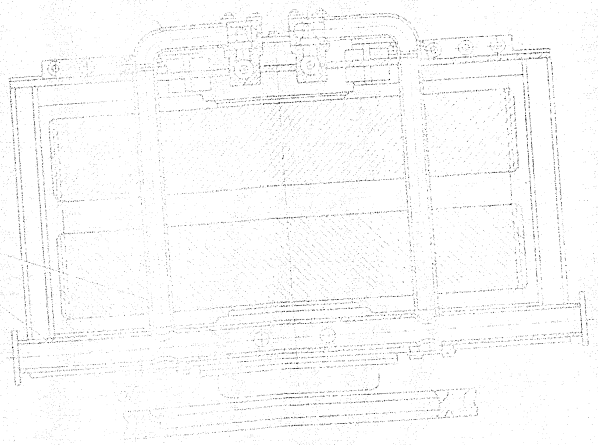

FIG. 11

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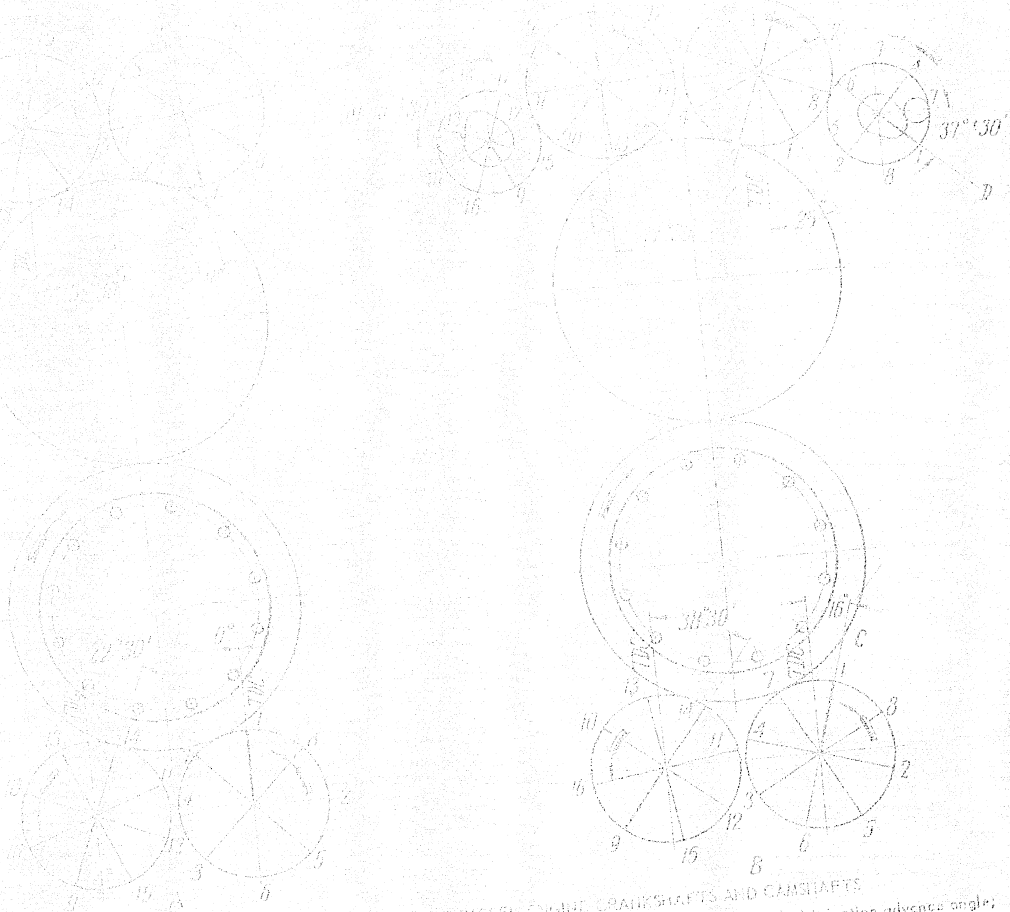

FIG. 12. ARRANGEMENT OF DIESEL CRANKSHAFTS AND CAMSHAFTS

A — arrangement of crankshafts (stern view); B — arrangement of camshafts (stern view); C — fuel injection advance angle; D — fuel injection pump starts injecting fuel at 30°30' before TDC of the cam plate (fuel injection pump plunger)

1, 2 — The fuel injection advance angle of 16° is adjusted during the first assembly of the diesel engine. During operation, overhauls and repairs, the advance angle is to be set in accordance with the check notches within the values specified in the Service Log.

All the pipes along which oil circulates (except for pipe 40) are welded into the drive housing (Fig. 11). From pipes 19, 28, 25 the oil gets into circular grooves 33 made in the beds intended for the bearings of gear 5 and then through bushing holes 34 it flows to lubricate the bearings. The bearings of gear 5 are also lubricated with oil from pipes 21 and 20, while the locating bearings are lubricated with oil flowing out from the outer end faces of the supporting bearings of gear 5.

The stern bearings of gears 1 are closed with caps 7, 17 and 31 made of aluminium alloy. The oil from the stern bearings of gears 1 gets into the drive housing through the splines cut on the stern end of shaft 5, through holes 9 available in gears 1, and also through flange holes 32 and housing holes 37.

Hole 54 made in flange 50 permits overflow of oil into the drive housing. The oil flowing out from the stern end face of the stern bearing of gear 5 is directed into the drive housing via passage 43. Oil from the bow end faces of the drive bow bearings is drained right into the engine sump. Since the remaining oil used to lubricate the drive flows into the drive housing lower box, whence it is sent back into the sump through pipe 40,

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MAJOR ACCESSORIES DRIVE

The oil pump, the fresh and sea water pumps, and the turbo-supercharger installed on the engine are driven by an independent unit, namely a double-stage reduction gear. The drive is enclosed in a separate housing fastened to the bow end face of the diesel engine frame.

The reduction gear first stage drives the oil and water pumps, whereas the other stage (a step-up gear with a large gear ratio) transmits additional torque for driving the turbo-supercharger through the fluid coupling.

The first stage of the diesel engine drive includes two gears 11 (Fig.13a), intermediate gear 9 engaging these two gears, two gears 12 meshed with gears 11, and gear 31 (Fig.13b) engaged with gear 9 (Fig.13a).

Gears 12 rotate the water pumps through couplings 36, while gear 9 drives the oil pump through coupling 32.

Torsion shaft 16 (Fig.13b) connects the diesel portside lower crankshaft to gear 11 (Fig.13a). Gears 11 run in bearings 34 and 35 (Fig.13b). The bushes and housings of bearings 35 are of a split design.

The second stage of the major accessories drive is connected to the first stage by torsion shaft 16 and includes driving gear 15, two intermediate gears 17 and 20, and driven gear 21.

The two-chamber fluid coupling ensures elastic connection between the diesel engine and turbo-supercharger. It comprises driving rotor 26, driven rotor 27 and drum 25. Thrust bolt 28 carries the axial force produced by oil pressure against the end face of gear 21. The fluid coupling driven system together with the turbo-supercharger rotor are balanced dynamically during assembly.

The housing of the major accessories drive consists of five welded housings 24, 29, 33, 30, 13, and covering 7 (Figs 13a, 13b) of upper crankshaft dampers. The housing joints are sealed by means of special sealing compound "Hermetic".

The joint faces of the housings are made so that all the gear bearings (save for two bearings 35) are of the solid type. The bearing bushes are really bushings lined with antifriction alloy.

Housing 30 (Fig. 13b) of the outboard bearing makes it possible to carry out partial disassembly of the drive without disconnecting it from the diesel engine frame.

The low-pressure housing 33 has the following finished flats: flange 1 for attaching the water pump, flange 2 for attaching the oil pump, and pad 3 for mounting the turbo-supercharger.

Housing 33 is provided with safety valves similar to those fitted in the side covering 5 of the diesel engine (see Fig.3) are available in the side walls of lower steel housing 33 (Fig. 13b). Lower housings 13 and 29 have lugs for securing the drive to the ship foundation. Clamps for securing the end face shock absorbers are welded to the bow side of lower housing 33.

On the side of the diesel engine frame, the lower part of housing 13 forms the casing of the lower [illegible]

[illegible] fluid coupling (see Fig.13b), is fed [illegible] housing 30 connected to the lower inside surface of [illegible]

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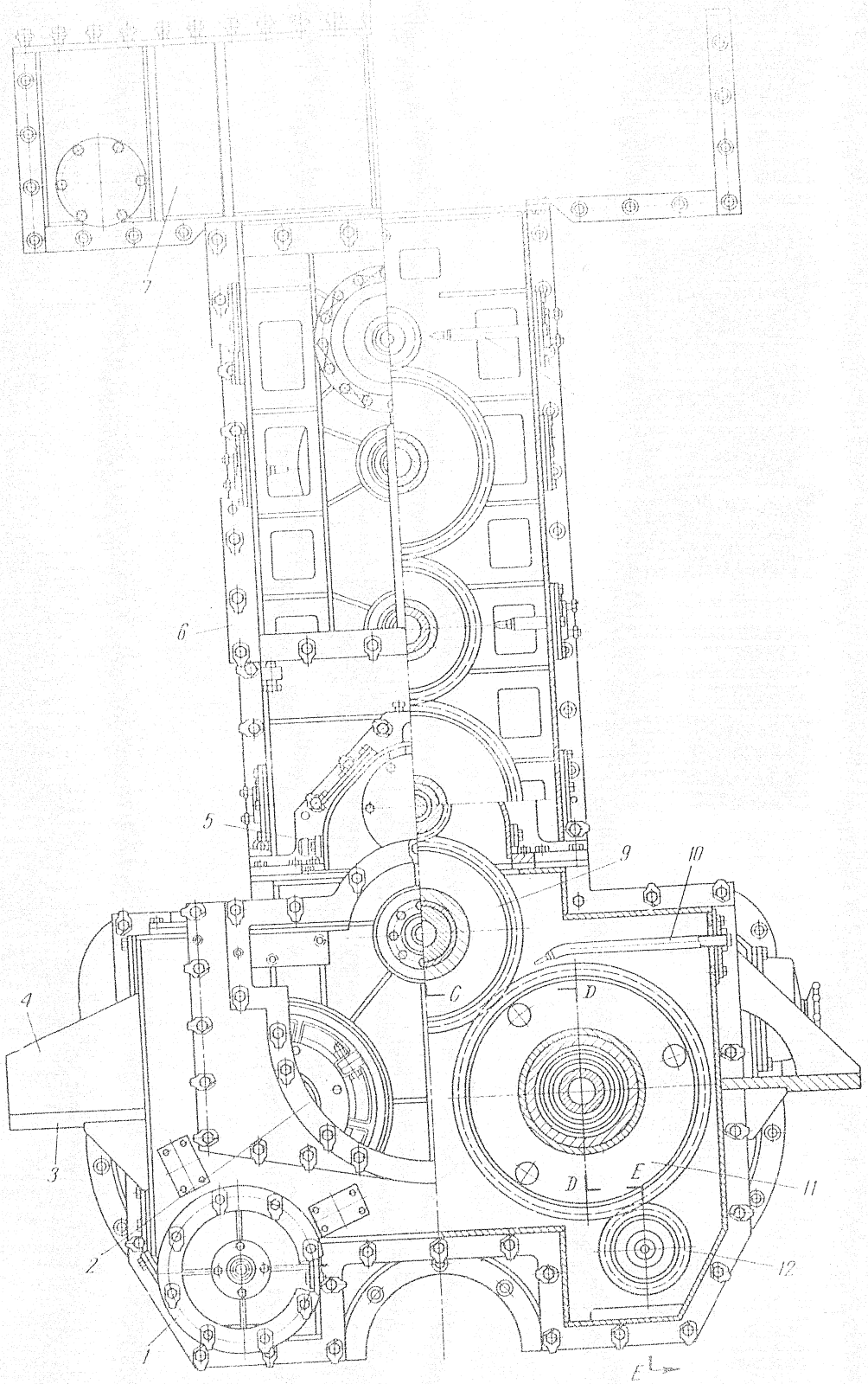

FIG. 13a GENERAL VIEW OF MAJOR ACCESSORIES DRIVE

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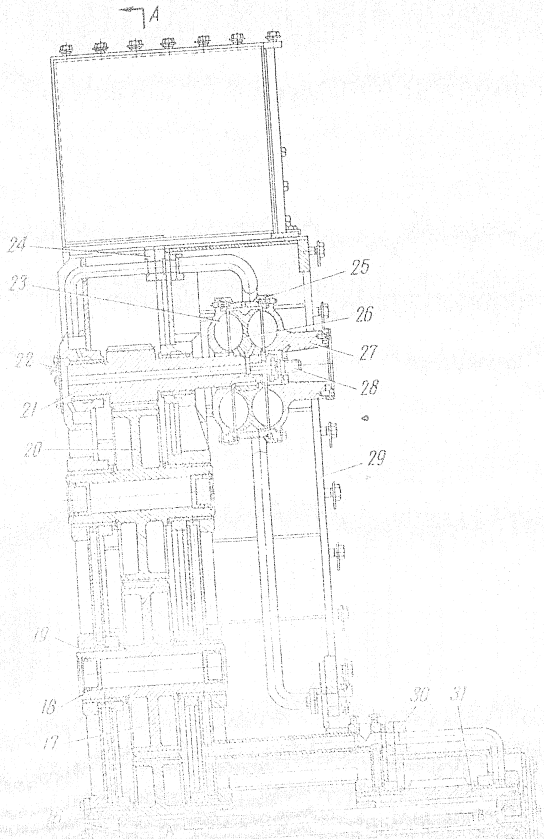

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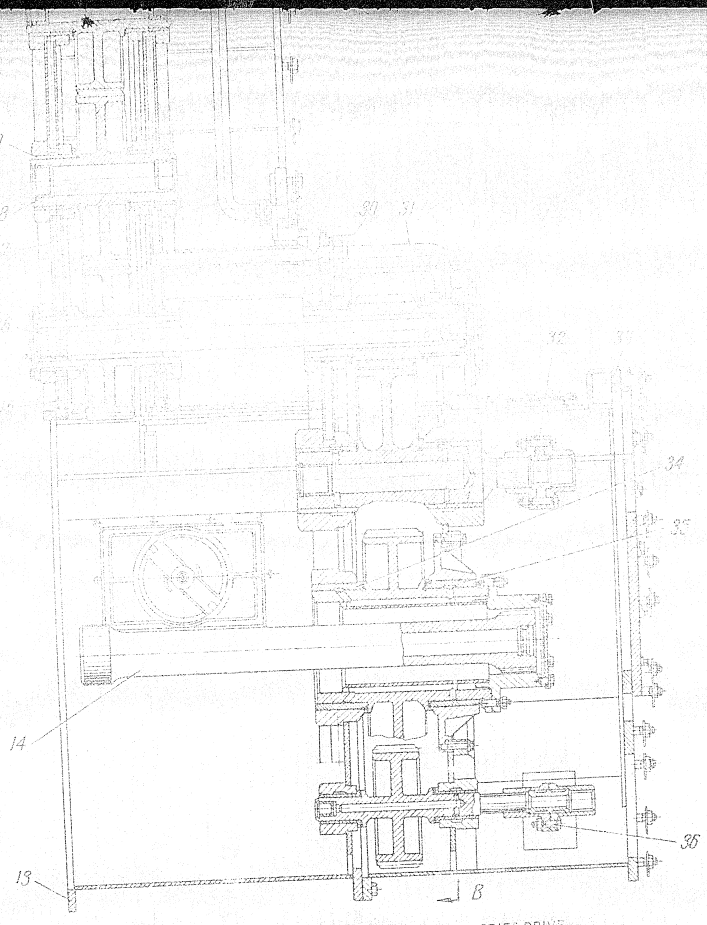

FIG. 13L. LONGITUDINAL SECTION OF MAJOR ACCESSORIES DRIVE

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From the distributing boxes the oil flows as follows:

(a) along pipes 39 to the housing, whence it runs through pipes welded into the housing to the engagement unit bearings and to the drive gears of the water and oil pumps;

(b) along pipes 42 to the housing, and further it runs through pipes welded into the housing to lubricate the bearings of the drive second stage gears, except the bearings of gear 21 (Fig.13b);

(c) along pipes 44 (Fig.13c) to the housing, and further it is directed through pipes welded into the housing to lubricate the bearings of driven gear 21 (Fig.13b) of the turbo-supercharger drive, and also to supply the fluid coupling;

(d) to lubricate the drive gear teeth along pipes 38, 40, 41, 43, 45, 46 and 47 welded to the hatch covers.

MINOR ACCESSORIES DRIVE

The minor accessories drive (Figs 14a, 14b) is essentially a reduction gear which drives the following accessories mounted on its housing:

(a) speed governor 3;

(b) starting air distributors 4;

(c) summating revolution counter 2;

(d) electric tachometer generator 1.

Drive housing 13 and covers 12 and 19 are cast of aluminium alloy. Housing 13 is attached to the flange of the housing of the diesel engine main drive intermediate gear stern bearing. Electric tachometer generator 1 is installed on the bracket of cover 12, while the other accessories are mounted on respective pads of the drive housing.

Rotation is transmitted to the drive from the end face of the main drive intermediate gear through a cam coupling, whose driving cams are made on the main drive intermediate gear flange, while the driven cams are on driving shaft 25 of the drive. Textolite washer 17 is placed between the driving and driven cams. Driving bevel gear 21 is keyed to shaft 25. This gear transmits rotation to three bevel gears 18, 40 and 41 simultaneously. The speed governor is actuated by bevel gear 18 through splined shaft 16 and coupling 14. Axial travel of coupling 14 is prevented by pin 15.

Gear 44 keyed to the shaft of bevel gear 41 drives the air distributors through gears 7.

Gear 33 is rotated by bevel gear 40 keyed to the shaft of gear 37.

Summating revolution counter 2 is driven by bevel gear 33 through a spring coupling. Coupling driving part 10 gets with its pin 11 into gear shaft slot 8, while driven part 9 is screwed to the shaft of the revolution counter. Gear 33 drives also bevel gear 36, whose shaft carries spur gear 35 transmitting the torque to gear 29. The shaft of this gear actuates the electric tachometer generator through a spring coupling similar to that used for actuating the revolution counter. Gear 29 is provided with oil deflecting lug L. Leakage of oil along the gear shaft is prevented by oil seal 32.

Each shaft of the above gears runs in antifriction bearings pressed into steel collars 20, 26, 26, 31, 34, 39 and 42.

One of the bearings (ball bearings) runs over the axial forces. The collars are fitted into the seats of housing 13 and are secured either by pressure flanges 23 and 38 which press collars 26 and 39 through the ball bearing outer races, or by strips 22 and 27 which clamp collars 20 and 31 through intermediate caps 24 and 30 pressed into the bottom of these collars, or by set screws 43 which lock the collars of the other gears.

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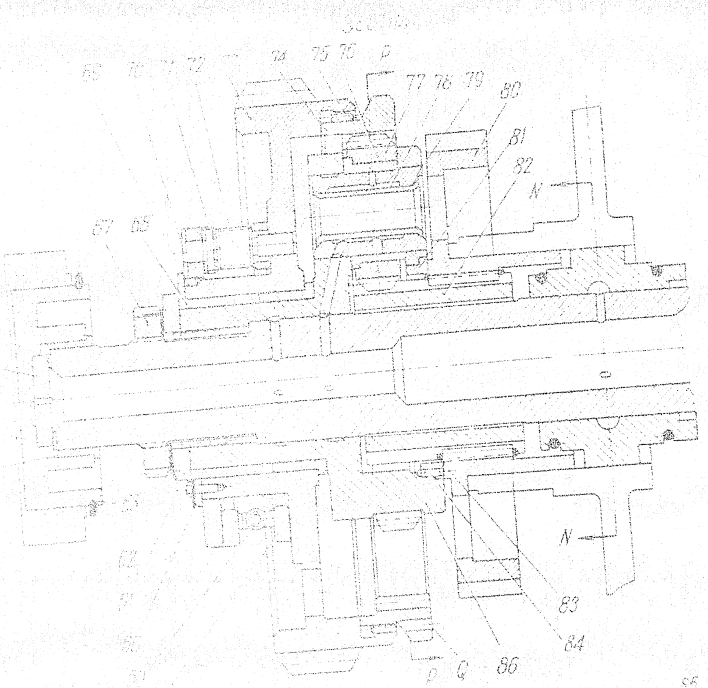

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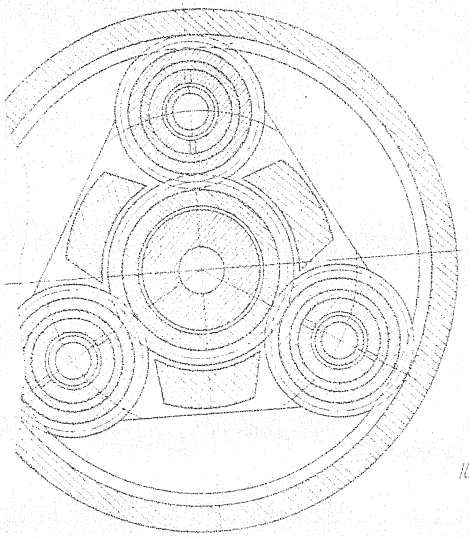

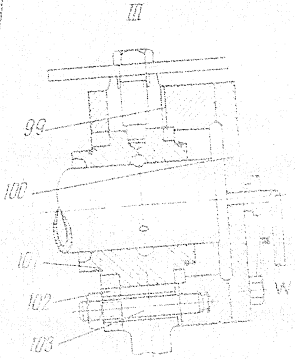

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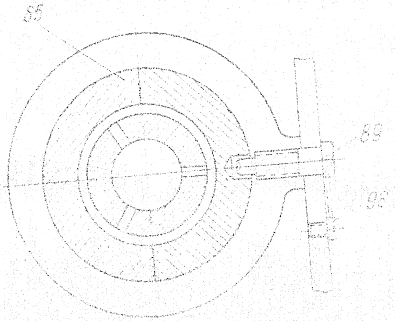

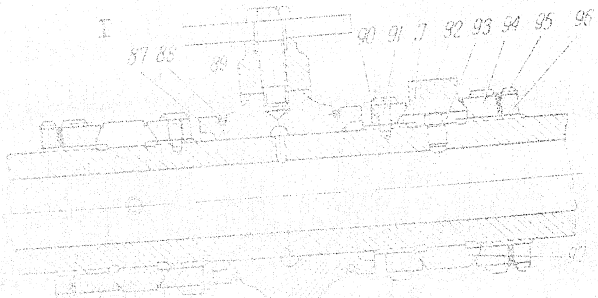

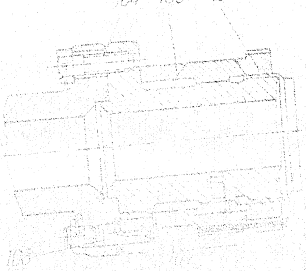

FIG. 18. CAMSHAFT WITH DRIVE

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Each camshaft runs in two end bearings 52 and 57, one starboard (thrust) bearing 51 and seven supporting bearings 56, all the bearings being identical in the frame wall bores.

The supporting and end bearings consist of cast-iron bushes 85 and 87 forged of aluminium alloy and tightened up on the cam shaft by two steel straps 88. Bushes 85 and 87 forged of aluminium alloy screw 89 with hexagonal ends. Pin 86 prevents rotation of the bushes 85. Half-bush 87 has a hole for locking on by means of screw 89.

Starboard bearing 51 comprises steel housing 55, into which bronze bushing 64 is pressed and bronze ring 66 is forced. Pin 50 and elastic ring 65 keep housing on against axial travel and turning.

Each camshaft carries sixteen split cam plates 54, to fit the number of fuel injection pumps in one engine cylinder row. The cam plates are of symmetrical shape, with case-hardened and quenched working surfaces. Both cam plate halves 92 and 97 are tightened up on the shaft by means of taper nuts 90 and 94. Nut 90 is locked by screw 91, while nut 94 is secured by means of locknut 96 provided with tab washer 95. At the flange of camshaft bow half 58 the cam plate is clamped between ring 105 and nut 106 which is tied with wire to prevent rotation. Ring 105 is locked by pin 107.

Mutual location of the cam plates on the camshaft and of the cranks on the lower crankshafts is the same, and is determined by pins 93 which are pressed into the camshafts and get into cam plate slots I spaced precisely with regard to the lobes.

Camshaft drive. The camshafts are driven by the upper crankshafts whose toothed couplings are engaged with driving gears 46 and 73 of planetary mechanisms 1 and 6. Bronze bushings 68 are pressed into the gear hubs. Carriers 86 of these mechanisms are spline-fitted on the journals of the camshaft stern ends. The splines of carrier 86 are pressed to the shoulder of camshaft half 53 by means of nut 67, due to which the carrier is secured relative to the camshaft. Both planetary mechanisms (portside 1 and starboard 6) are of a similar design and differ from each other only in the over-speed governor transmitter. The transmitter is built into driving gear 73 of one of the planetary mechanisms located on the side of the diesel engine emergency control station.

Axial travel of gears 46 and 73 is limited on one side by the shoulder of carrier 86, and on the other side by splined ring 61 pressed to the carrier tang end face by means of nut 67 which is locked by tab washer 62.

Crown 74 splined with the driving gears is held against axial travel by elastic ring 75. Holes Q made in the crown are used for dismounting the elastic rings.

Planet pinions 77 come into mesh with crown 74 and sun gear 82 simultaneously. Bronze bushings 76 of these planet pinions rotate on hollow pins 79 pressed into carriers 86.

Gears 46, 73, 82, crown 74 and pinions 77 are made of alloy steel and the working surfaces of their teeth ensure high hardness.

The tang of gear 80 is loose-fitted into the bed of the camshaft stern bearing.

Axial travel of the camshaft is prevented on one side by gear 80 whose end face contacts bronze bushing 81, and on the other side by bronze ring 66. Pin 84 secures bushing 81 with regard to the carrier.

Grooves G cut on the camshaft stern end face serve for producing an oil wedge. Axial clearance in the camshaft thrust bearing is ensured by varying the thickness of ring 66.

Oil is fed to the camshaft and its drive through cover 100 fitted on studs 103. Two half-rings 102 are placed under the stud nuts. The cover is sealed by gasket 99.

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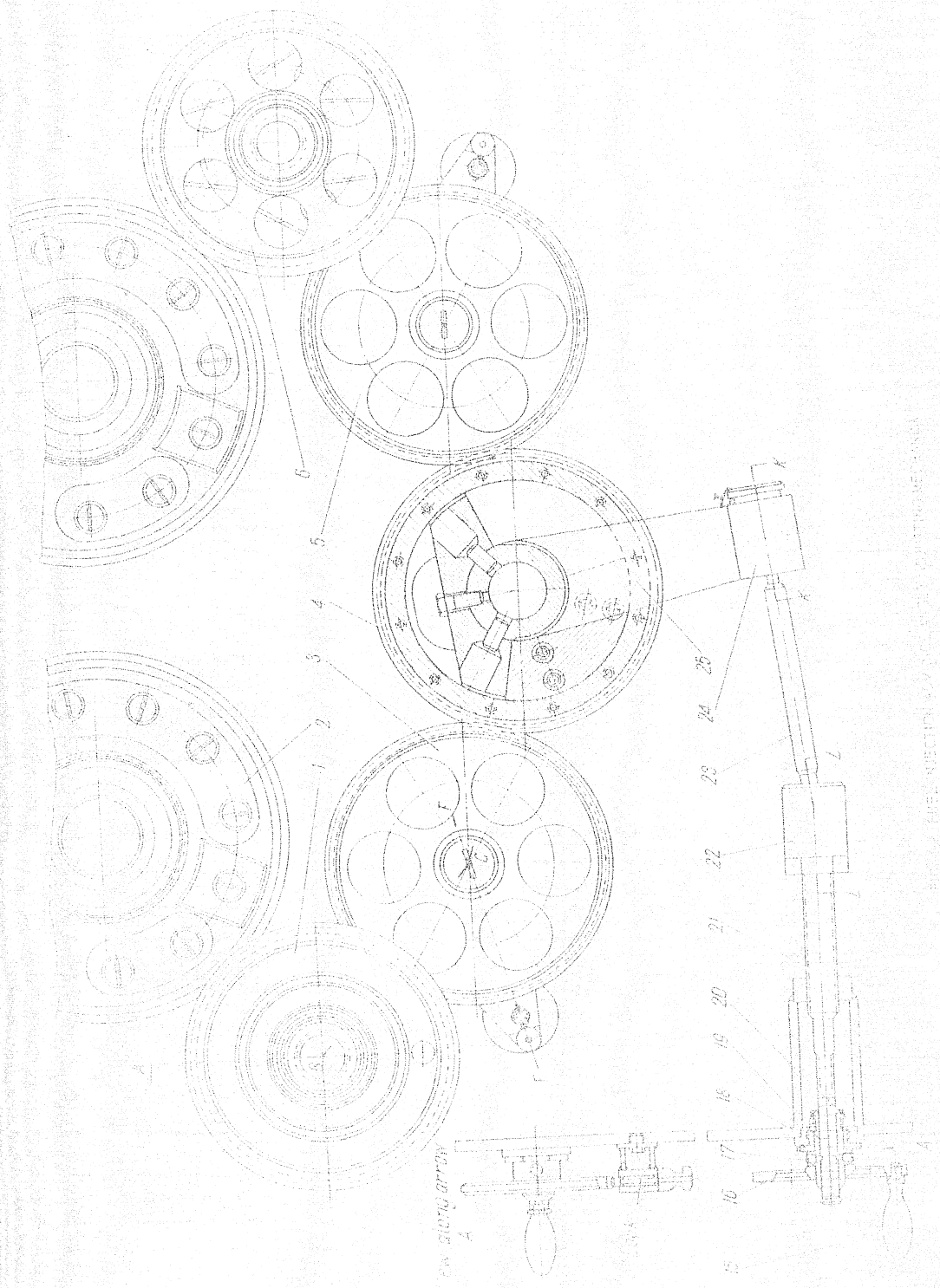

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From the cover the oil [illegible] the working surfaces of [illegible] surface of carrier 80. [illegible]

From the carrier's [illegible] ages of driving gears 48 and 73, the [illegible] splines of crown 74. From the [illegible] table on the outer surfaces of [illegible] the cavity between the pin and collet rods 78. The oil gets into the pin inner cavity through two radial drillings to lubricate bushings 76 and the teeth of planet gears 77, crown 74 and sun gear 82.

The driving gears are lubricated by splashing.

[illegible] drillings to lubricate the bear- [illegible] bearings lubricates the [illegible] drillings into the grooves avai- [illegible] drilled passages into

FUEL INJECTION ADVANCE ANGLE ADJUSTING MECHANISM

The fuel injection advance angle adjusting mechanism allows to alter the fuel injection advance angle for all the fuel injection pumps simultaneously, simultaneous turn of both camshafts changes the location of cam plates relative to the cranks of the crankshafts. The fuel injection advance angle may be adjusted during diesel engine operation. The adjusting mechanism is structurally joined with the camshaft drive planetary mechanisms and consists of buffer gear 4 (Figs 15a, 15b, 15c), two intermediate gears 3 and 5 meshed with planetary mechanism gears 80, lever 25, two ball-and-socket hinges 22 and 24, screw 21, handwheel 16 with handle 15, and rod 23.

Gears 3 and 5 are loose-fitted on trunnions 12 secured on the diesel engine frame wall. Axial travel of these gears is prevented by mushroom-type cap 13 held in trunnion 12 with the aid of screw 14, and also by stop 7. Lock 9 provided with knob 11 and spring 10 keeps the stop (when in operating position) against rotation around stud 8.

When stop 7 is turned through 90° (for which purpose lock 9 should be moved out of its seat), gear 3 (or 5) moves towards the frame as far as the shoulder of trunnion 12 permits. Gear 3 (or 5) disengages herein from planetary mechanism gear 80, but remains meshed with buffer gear 4. Buffer gear 4 comprises slide block 45 and rim 35 bolted to two discs 33.

FIGS 15a, 15b, 15c. CAMSHAFT WITH DRIVE AND FUEL INJECTION ADVANCE ANGLE ADJUSTING MECHANISM

1 – portside planetary mechanism; 2 – toothed rim of upper crankshaft coupling; 3 – intermediate gear; 4 – buffer gear; 5 – intermediate gear; 6 – starboard planetary mechanism; 7 – stop; 8 – stud; 9 – lock; 10 – lock spring; 11 – lock knob; 12 – trunnion; 13 – mushroom-type cap; 14 – screw; 15 – handle; 16 – handwheel; 17 – screw; 18 – bush; 19 – handwheel hub; 20 – nut; 21 – screw; 22 – ball-and-socket hinge; 23 – rod; 24 – ball-and-socket hinge; 25 – lever; 26 – pin; 27 – washer; 28 – hinge body; 29 – bolt; 30 – slide block; 31 – pin; 32 – bolt; 33 – ring; 34 – elastic ring; 35 – buffer gear toothed rim; 36 – disc; 37 – trunnion; 38 – bushing; 39 – nut; 40 – stud; 41 – collet-type bushing; 42 – key; 43 – nut; 44 – lever bushing; 45 – slide block; 46 – planetary gear of planetary mechanism; 47 – bolt; 48 – nut; 49 – stop; 50 – pin; 51 – camshaft outboard bearing; 52 – camshaft end bearing; 53 – camshaft stem half; 54 – cam plate; 55 – camshaft bow half; 56 – [illegible] bearing; 57 – end bearing; 58 – [illegible] governor spring; 60 – pressure ring; 61 – splined ring; 62 – tab washer; 63 – elastic ring; 64 – bushing of outboard bearing; 65 – housing of outboard bearing; 66 – thrust ring; 67 – nut; 68 – bushing; 69 – pin; 70 – flange; 71 – pin; 72 – speed governor gear; 73 – driving gear of planetary mechanism; 74 – crown; 75 – elastic ring; 76 – bushing; 77 – planet gear; 78 – oil tapering pipe; 79 – pin; 80 – gear; 81 – bushing; 82 – sun gear; 83 – elastic ring; 84 – pin; 85 – half-bush; 86 – carrier; 87 – half-bush; 88 – elastic ring; 89 – locking screw; 90 – taper nut; 91 – screw; 92 – cam plate half; 93 – pin; 94 – taper nut; 95 – tab washer; 96 – nut; 97 – cam plate half; 98 – screw; 99 – gasket; 100 – cover; 101 – half-bush; 102 – half-ring; 103 – stud; 104 – bolt; 105 – ring; 106 – nut; 107 – pin; 108 – taper bolt; W – pipe union for [illegible] the pressure of oil in camshaft supply chamber

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The slide block is also connected to discs 36 by means of calibrated bushings 41 and studs 40 provided with nuts 39. Buffer gear 4 is loose-fitted on bushing 44 of welded lever 25. Stop 49 attached to lever 25 by means of bolt 47 and two pins 48 passes freely between discs 36 and into the inner surface of rim 35. Stop 49 and slide block 45 occupy only part of the buffer gear inner space; the remaining space is filled with oil which gets inside via holes C made in discs 36. This oil lubricates also buffer gear rim 35 and gears 3 and 5.

Lever 25 is loose-fitted on bushing 38 secured to the engine frame wall by trunnion 37 provided with nut 43. Axial travel of lever 25 is limited by the shoulder of bushing 38 and by nut 43. Rod 23 provided with two ball-and-socket hinges 22 and 24 links up lever 25 with screw 21 driven into the frame side wall. Each hinge consists of ball 32 screwed on the rod and held to it by pin 31, two slide blocks 30 and ring 33.

The necessary clearance in the hinge is obtained by changing the thickness of ring 33. The parts of ball-and-socket hinge 24 are assembled in a sleeve welded to lever 25, and are tightened up by means of bolt 42 which is tied with wire to prevent it from unscrewing. The parts of ball-and-socket hinge 22 are tightened up with the aid of screw 21 between elastic ring 34 and washer 27 inside hinge body 28 held to screw 21 by pin 26.

Handwheel 16 with handle 15 is fitted on the shank of screw 21 provided with two longitudinal splines. Handwheel hub 19 rotates freely in nut 18 and is held against axial travel by nut 20. Two screws driven into the hub secure the latter with regard to screw 21. When screw 21 is turned, it rotates axially in the diesel engine frame and thus turns lever 25 and stop 49.

The torque applied to the camshaft for its rotation, imparts a reactive torque to sun gear 82, and this causes a turn of camshaft gears 80, 3, 5 and of buffer gear rim 35 until slide block 45 and stop 49 come into contact. Hence, the angle between the inner dead center of any crankshaft crank and the cam plate lobe of the fuel injection pump of the respective cylinder depends on the position of screw 21.

To alter the fuel injection advance angle, move the lock out of the slot made on the rim of handwheel 16, and rotate the handwheel with the aid of handle 15. During clockwise rotation of the handwheel the following takes place: screw 21 gets deeper into the frame and turns herein lever 25; stop 49 presses against slide block 45 and turns buffer gear rim 35 and, consequently, sun gear 82 meshed with it; as a result the advance angle will increase.

To reduce the advance angle rotate handwheel 16 counter-clockwise. In this case, stop 49 will recede from slide block 45, the sun gear actuated by reactive torque will turn the stop until it contacts the slide block, and will thus turn the camshaft relative to the crankshaft.

OVERSPEED GOVERNOR TRANSMITTER

The overspeed governor transmitter is mounted in one of the planetary mechanisms of the camshaft drive (see Figs 15b and 16). The transmitter consists of two weights 58 which are suspended from the axle of gears 72 and embrace the hub of driving gear 73. The weights are balanced by side spring B. The hub of gears 72 is pressed with one of its ends into each weight 58 and is secured there by pin 71. Gears 72 are meshed with each other so that they allow the weights to move apart at an equal distance. Driving gear 73 and flange 70 which is fitted on the hub of gear 73 and pressed to its end face by pressure ring 60 serve as bearings for the gears. Pin 69 keeps flange 70 against rotation.

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As soon as the engine develops a speed [illegible] the governor weights 56 actuated by centrifugal force start moving apart, overcoming the force of the spring 59, and the end of the weights actuates the striker of the governor actuating mechanism.

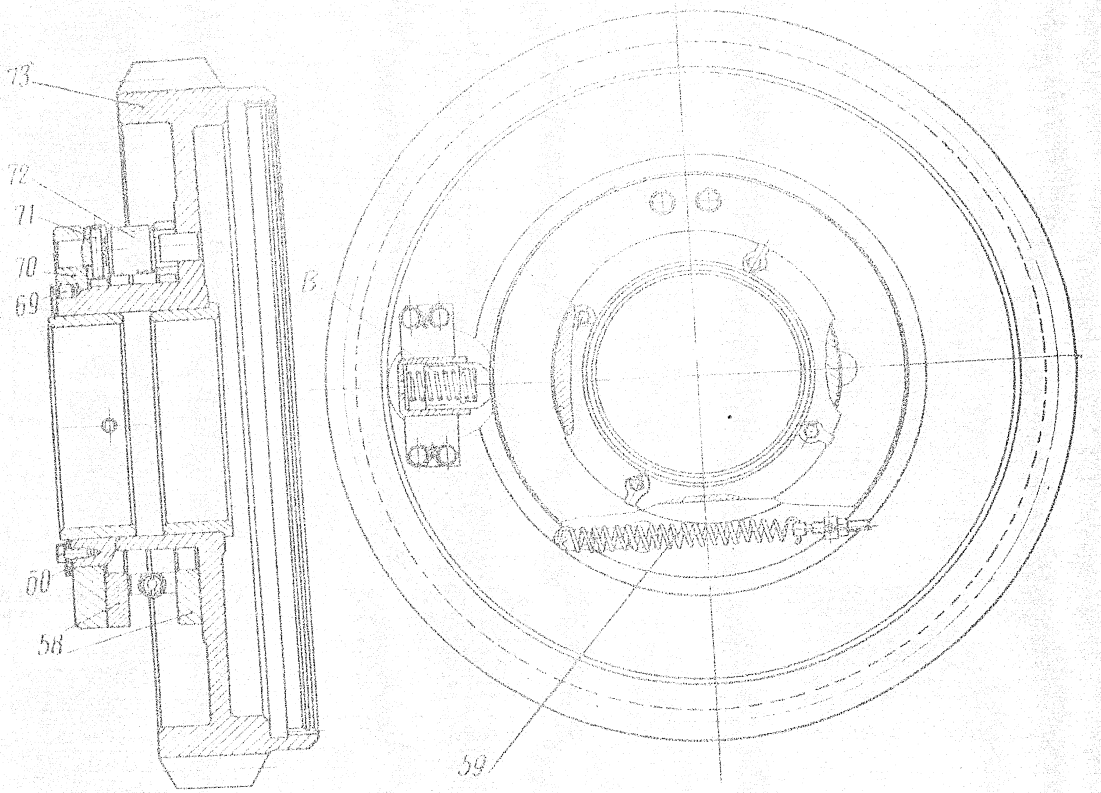

FIG. 16. GEAR WITH OVERSPEED GOVERNOR TRANSMITTER

56 – governor weights; 59 – spring; 60 – pressure ring; 69 – pin; 70 – flange; 71 – pin; 72 – gear; 73 – driving gear of planetary mechanism; B – spring

Under the effect of the received impulse, the actuating mechanism linked up with the fuel injection pump control shafts moves the shafts to a position in which the fuel feed will be shut-off. The actuating mechanism is described in Chapter X.

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Chapter V

GAS-AIR SYSTEM

Four-diesel engine gas-air system includes a turbo-supercharger (see Chapter VI), two air coolers with branch pipes, a scavenging air receiver, working cylinders, and gas exhaust manifolds.

WORKING CYLINDER

The working cylinder set comprises cast-iron sleeve 6 complete with flange 5 and jacket 9. The sleeves are mounted in the bores of the diesel engine frame horizontal shelves and are attached through flange 5 to the upper shelf with the aid of four studs (see Unit II in Fig. 1a). Detachable flange (Fig. 1/) is fastened to the sleeve by means of two half-rings 3, pressure ring 2 and twelve bolts 1.

The upper part of sleeve 6 enters the scavenging air receiver and has twenty ports for air to pass. The scavenging ports are made with an axial and tangential slope, to ensure swirling of the incoming air, which contributes to better mixing of fuel particles with air and also to proper removal of combustion products from the cylinder. The middle part of the sleeve outer surface is provided with longitudinal cast ribs which increase the sleeve stiffness and form passages for cooling water. Pressed over the ribs is steel jacket 9 which serves as a power band.

Two pipe unions 30 to connect the injectors and pipe union 12 for the starting valve are screwed into the sleeve with flanges so that they are available in the middle part of jacket 9. Pipe union 23 is made of carbon steel and is screwed into the sleeve hole for mounting the indicator valve. The pipe union is provided with a flange and a ready-screwed nipple union 25. Rubber gasket 29 ensures tightness of the joint between the flange of the union and the sleeve. Installation of pipe union 23 on the side of jacket 9 is made similarly to the installation of pipe unions 30 and 12 with rubber ring 15 placed between the flange of the union and the sleeve. Pipe unions 30 are cooled in the jacket by water.

The sleeve is fixed in the cylinder jacket by means of the flange and is sealed with a rubber gasket 4 applied between them.

To improve operation of the engine at low loads, provision for scavenging and exhaust manifold is made with opposition discharge and is timed exactly. The width of the load is chosen so that the edge of the exhaust valve plate 26 (see Fig. 1a) does not cover the port edges during operation.

The sleeve is provided with a flange with holes for the bolts of gas exhaust manifold section 31 and a hole is provided for the pin 27 (Fig. 1) to hold the sleeve from turning. Sealing rubber gasket 28

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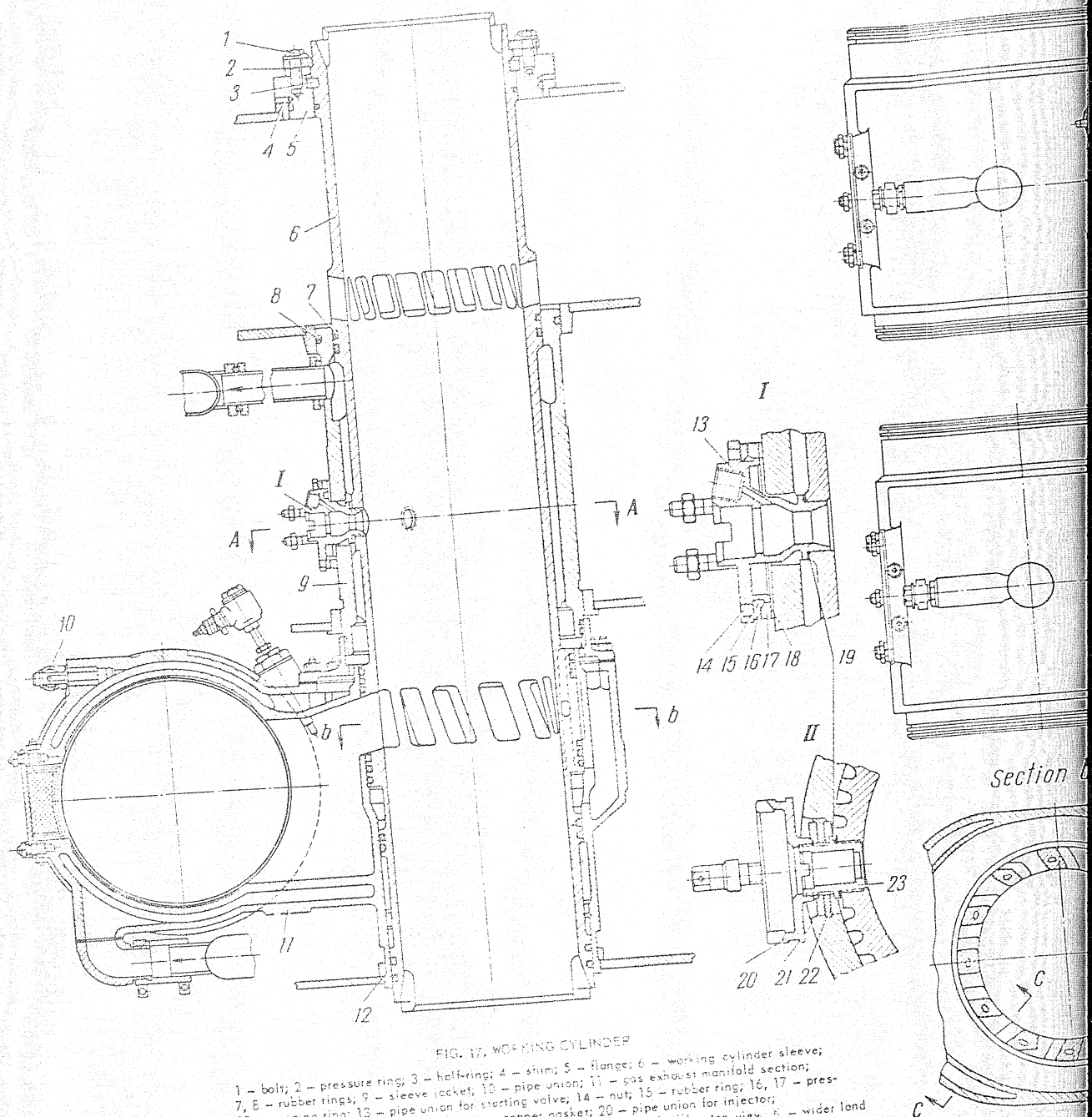

FIG. 17. WORKING CYLINDER

1 – bolt; 2 – pressure ring; 3 – half-ring; 4 – shim; 5 – flange; 6 – working cylinder sleeve; 7, 8 – rubber rings; 9 – sleeve jacket; 10 – pipe union; 11 – gas exhaust manifold section; 12 – spacing ring; 13 – pipe union for starting valve; 14 – nut; 15 – rubber ring; 16, 17 – pressure rings; 18 – rubber gasket; 19 – rose-copper gasket; 20 – pipe union for injector; 21 – pressure block; 22 – rubber gasket; 23 – pipe union; 24 – bolt; III – top view; K – wider land

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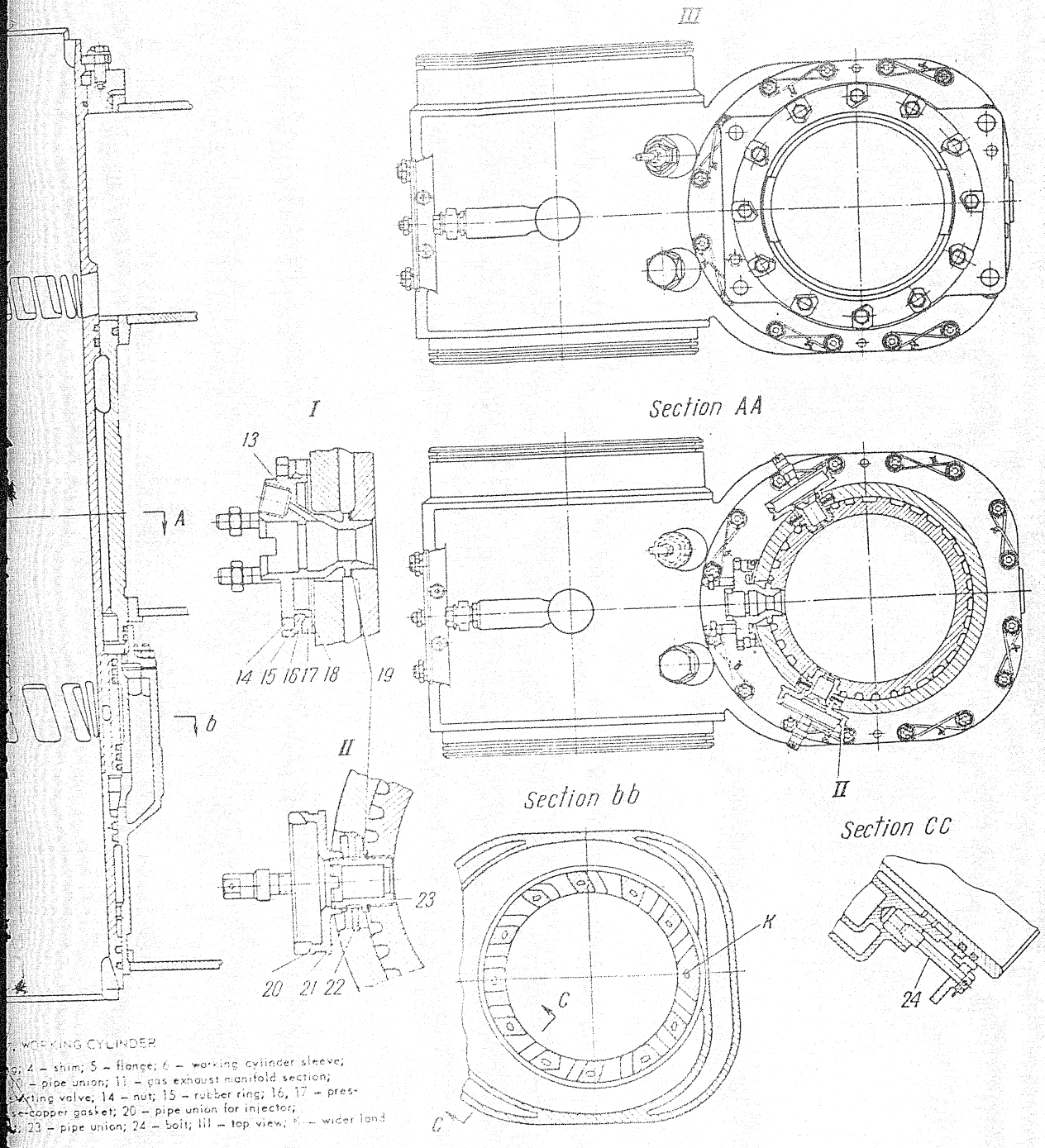

, WORKING CYLINDER

g; 4 – shim; 5 – flange; 6 – working cylinder sleeve;
– pipe union; 11 – gas exhaust manifold section;
exting valve; 14 – nut; 15 – rubber ring; 16, 17 – pres-
se-copper gasket; 20 – pipe union for injector;
; 23 – pipe union; 24 – bolt; III – top view; K – wider land

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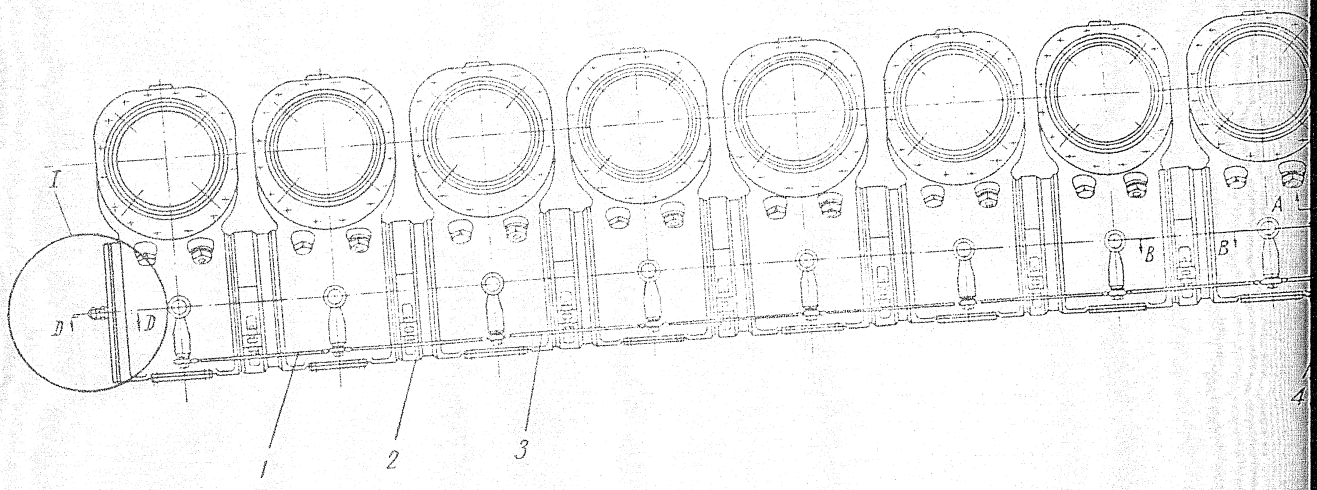
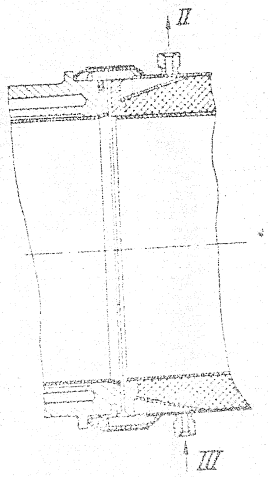
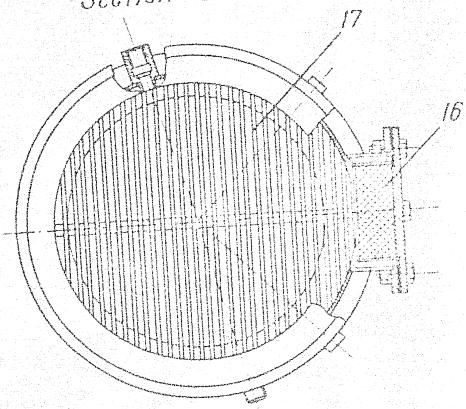


Section AA



Section CC



Section BB

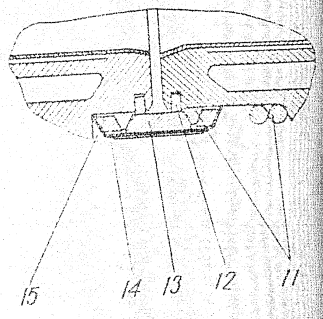


FIG. 19. GAS EXHAUST MANIFOLD

1 – manifold section; 2 – clip; 3 – rubberized-fabric pipeline; 4 – protective visor; 5 – pipe; 6 – pipe union for attaching the thermocouple; 7 – branch pipe; 8 – cover; 9 – rubber ring; 10 – pipe union; 11 – rubber ring; 12 – cast-iron 16 – cover; 17 – screen; 11 – w

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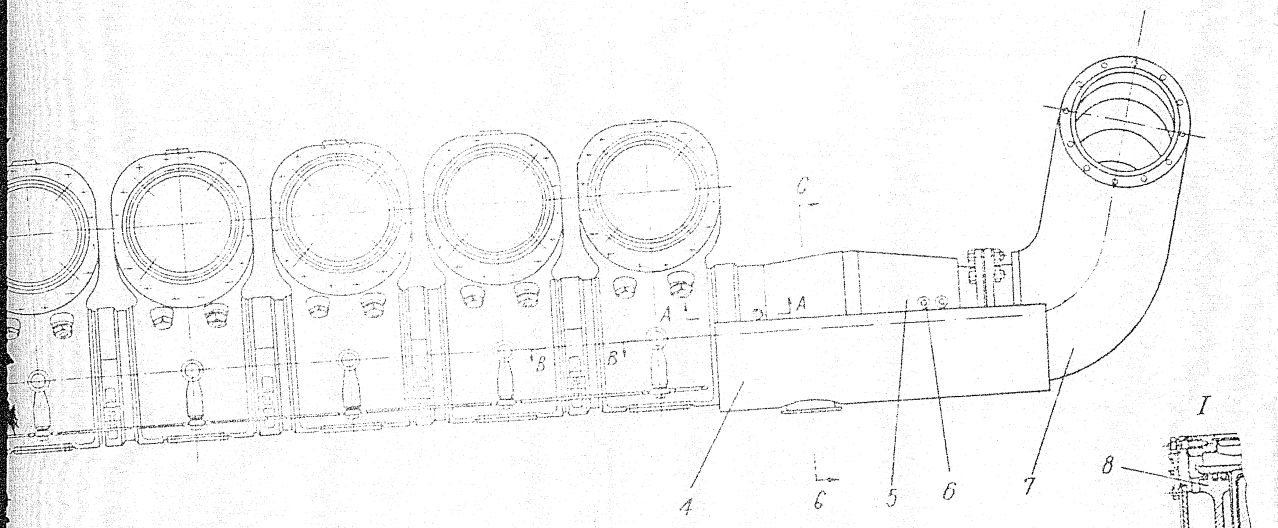

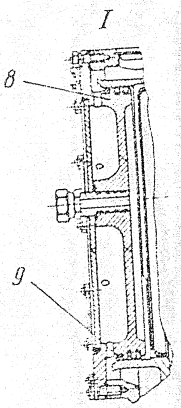

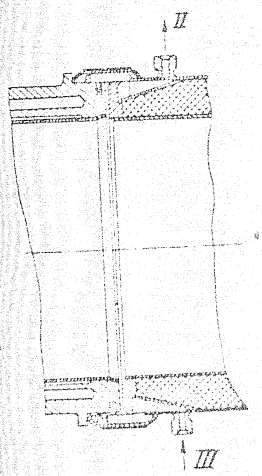

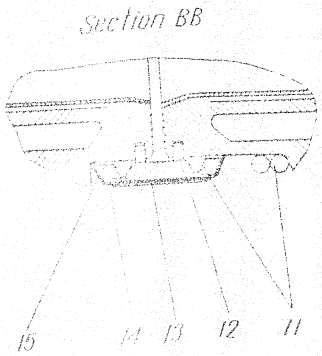

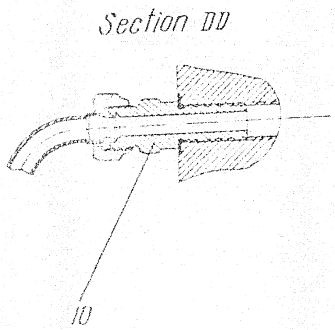

FIG. 18. GAS EXHAUST MANIFOLD

c pipeline; 4 – protective visor; 5 – pipe; 6 – pipe
e; 8 – cover; 9 – rubber ring; 10 – pipe union;
11 – rubber ring; 12 – cast-iron sealing ring; 13 – inner sealing ring; 14 – half-ring; 15 – ring;
16 – cover; 17 – screen; II – water outlet; III – water inlet

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The water cavities formed between sleeve 6 and jacket 9, as well as between the sleeve and manifold section 11, are sealed by rubber rings 7. Water passing of jacket 9 in the bores of the frame and the cover of section 11 is ensured by cuts in the upper part of exhaust ports is also sealed by means of rubber rings. Water flows from gas exhaust manifold section 11 to cool the lands between the exhaust ports, then it passes between the ribs of sleeve 6 and jacket 9, whence it is directed into the return pipeline via a hole made in the jacket upper part. The locating collars of jacket 9 are coated with a thin layer of lead.

Correct setting of sleeve 6 in height, with regard to the crankshaft axes, is done by changing the thickness of shim 4, while proper mounting of manifold section 11 relative to the sleeve exhaust ports is ensured by varying the height of spacing ring 12.

GAS EXHAUST MANIFOLD

Two exhaust manifolds (Fig.18) are installed along the diesel engine sides. Each manifold consists of eight interconnected sections 1, pipe 5 and branch pipe 7. Sections 1 are cast of aluminium alloy and are cooled by water.

Cooling water is also fed to the joint of pipe 5 (see section AA in Fig.18). Steel welded pipe 5 and branch pipe 7 are coated with heat insulation. Pipe 5 is provided with protective visor 4 for protecting the service personnel.

Due to sealing fitted between sections 1, the sections may expand axially during heating. The sealing (see section BB in Fig.18) comprises two cast-iron split sealing rings 12 fitted into grooves at the ends of each intermediate section, two rubber rings 11, two steel rings 15, steel inner sealing ring 13 and two half-rings 14 braced by means of clip 2 provided with two braces. Two rings 11 are loose-fitted on the section and serve as spare ones.

No rings 11, 12 and 15 are fitted in the joint between bow end section 1 and pipe 5 (on the side of the pipe), and inner ring 13 is welded to the pipe flange (see section AA in Fig.18).

The face of the stern end section is closed with cover 8 which is sealed in the section housing by means of one cast-iron ring 12 and two rubber rings 9. Oil and condensate accumulating in the manifold are discharged through pipe union 10 screwed into cover 8. Each side of the diesel engine carries two brackets which hold the manifold stern sections in place.

Screen 17 fitted in the middle part of pipe 5 prevents ingress of foreign matter (together with exhaust gases) into the turbo-supercharger. The condition of screen 17 is checked through a hand-hole closed by cover 16 provided with heat insulation.

Two pipe unions 6 for attaching the thermocouple are welded into the pipe upper part. Return of air and vapour from the manifold cooling cavities is exercised through pipeline 3 made of rubberized-fabric hoses.

The gas exhaust manifold section (Fig.19) is a casting made in the form of two pipes set at a right angle.

The vertical pipe serves as an exhaust box for the working cylinder sleeve, while the horizontal pipe is the exhaust path. The sections are of the double-wall type. Cooling water circulates along the space between the walls. Locating collars are bored in the vertical pipe to center the section relative to the cylinder sleeve. Water passage port D is made in the inner wall of the vertical pipe. The section is closed on top with cover 6 fastened by means of sixteen studs.

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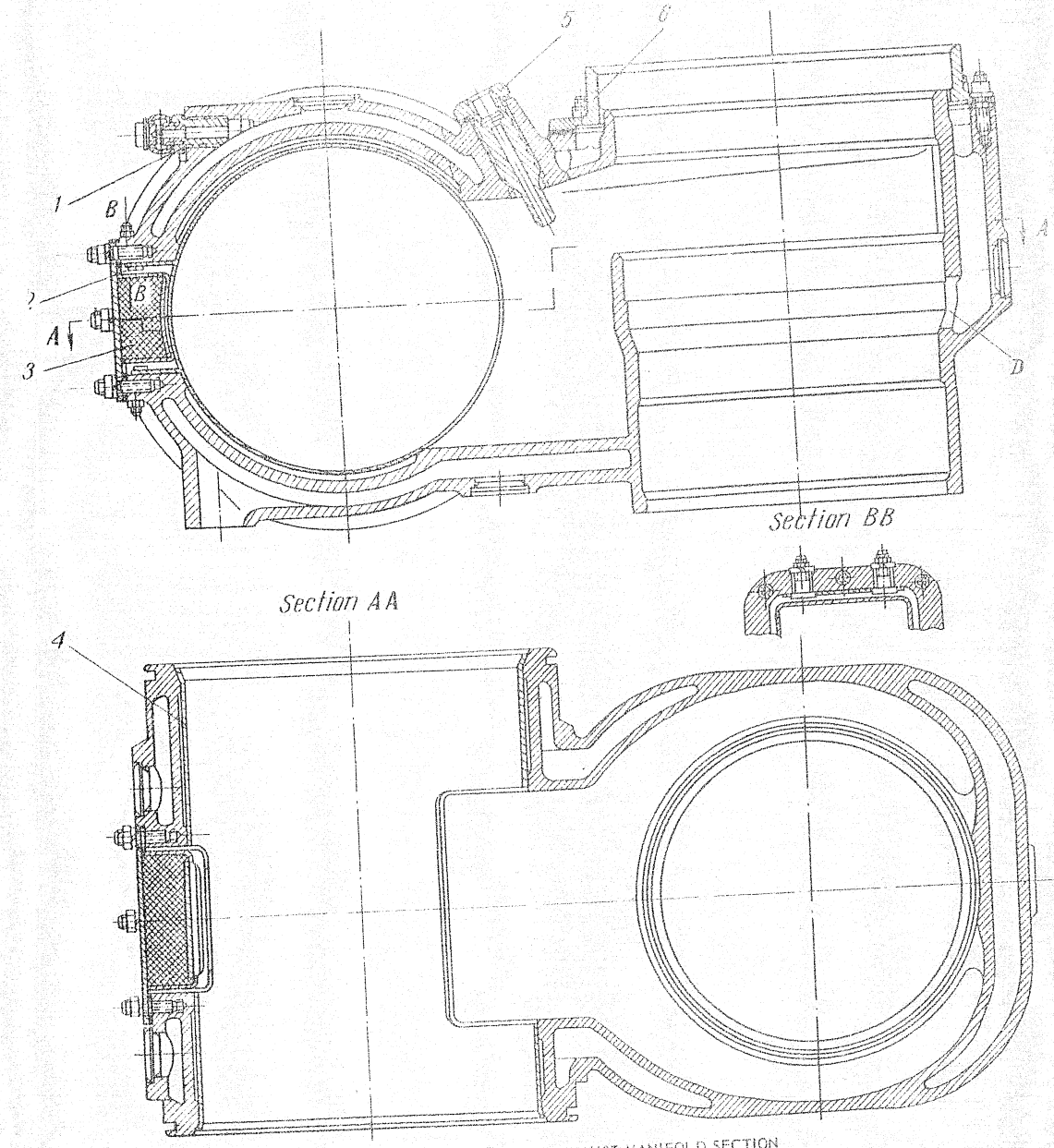

FIG. 19. GAS EXHAUST MANIFOLD SECTION

1 – pipe union; 2 – bolt; 3 – cover; 4 – steel pipe; 5 – pipe union for attaching the thermocouple; 6 – section cover; D – water port

To maintain the necessary temperature of exhaust gases, the horizontal pipe of each section houses heat-resistant steel pipe (shield) 4 secured to the section housing by means of four bolts 2.

Access into the section and inspection of the cylinder sleeve and piston through the exhaust ports are ensured through a handhole closed by cover 3 provided with heat insulation. Air and vapour are bled from the cooling cavities through a rubberized fabric hose attached to pipe union 1.

The section housing carries two bosses to mount pipe union 5 used for attaching the thermocouple. The choice of the boss depends on the section to be installed (starboard or portside).

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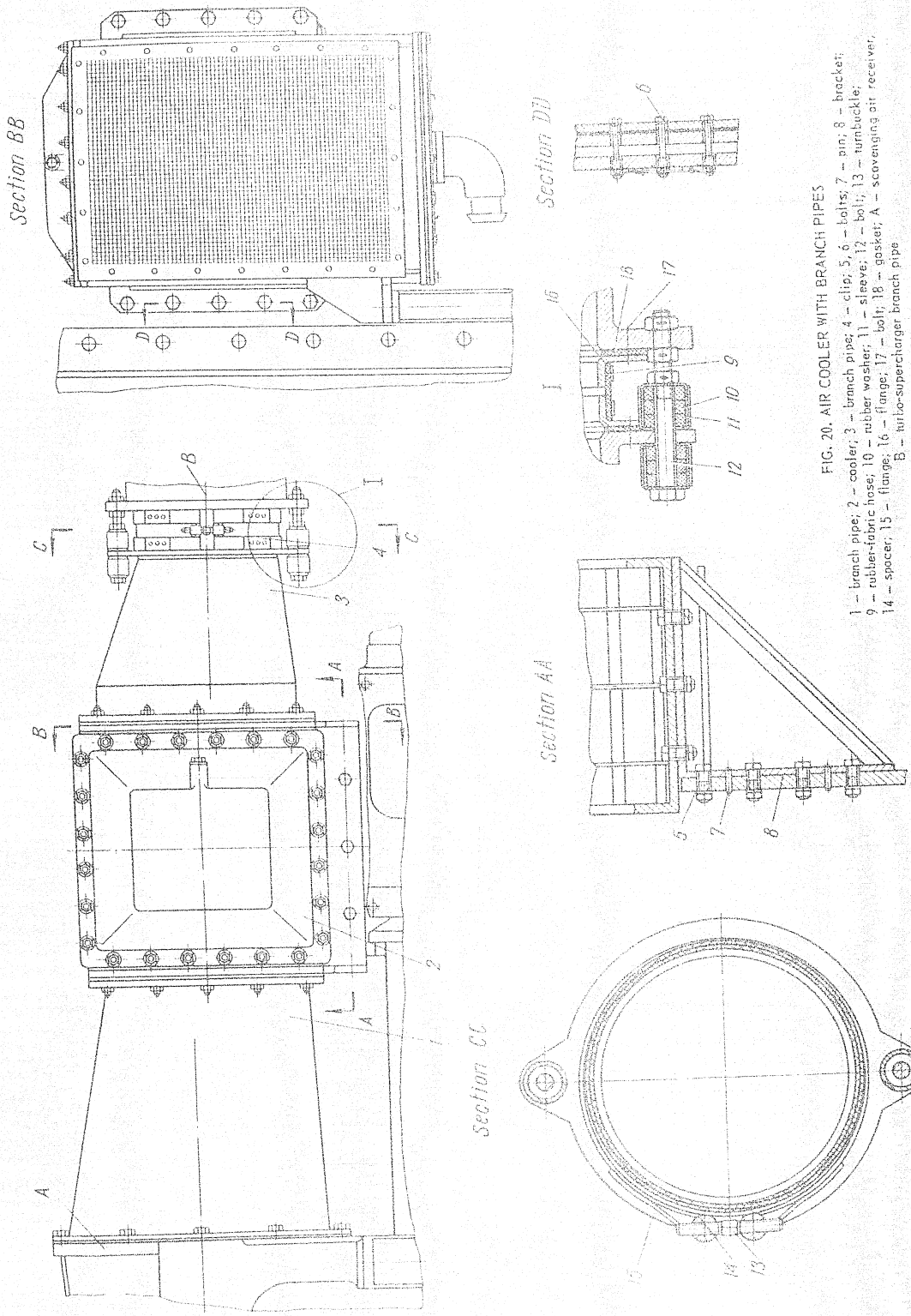

FIG. 20. AIR COOLER WITH BRANCH PIPES

1 – branch pipe; 2 – cooler; 3 – branch pipe; 4 – clip; 5, 6 – bolts; 7 – pin; 8 – bracket; 9 – rubber-fabric hose; 10 – rubber washer; 11 – sleeve; 12 – bolt; 13 – turnbuckle; 14 – spacer; 15 – flange; 16 – flange; 17 – bolt; 18 – gasket; A – scavenging air receiver, B – turbo-supercharger branch pipe

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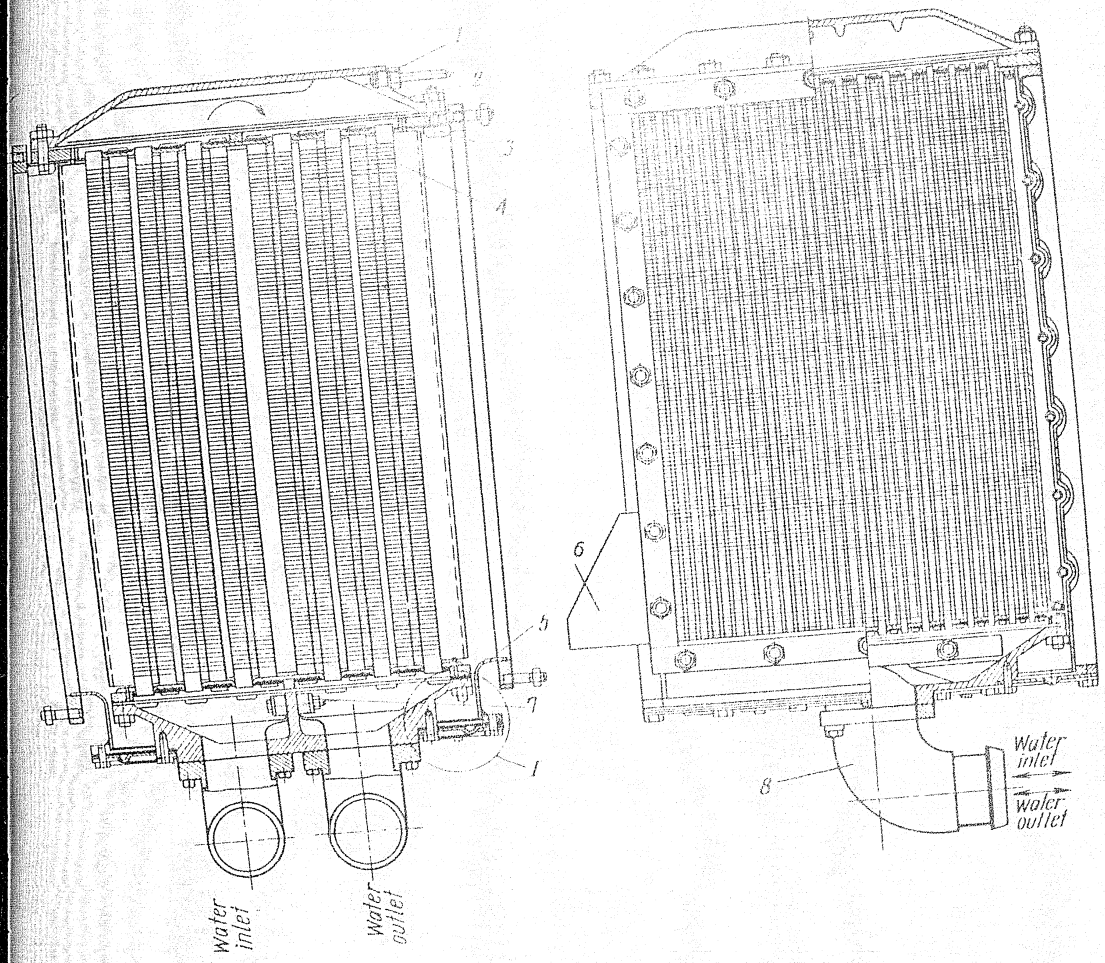

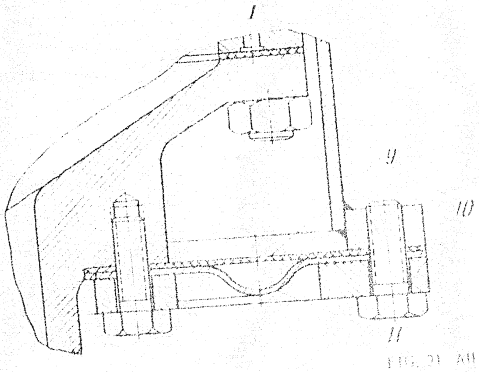

FIG. 21 AIR COOLER

1 – pipe union, 2 – upper cover, 3 – housing, 4 – pipe, 5 – lower cover, 6 – bracket, 7 – protector, 8 – cast branch pipe, 9 – gasket, 10 – spacer, 11 – blank plug

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AIR COOLER WITH BRANCH PIPES

Two air coolers together with welded branch pipes connecting them to the turbo-supercharger and scavenging air receivers are mounted in the bow part along the diesel engine sides.

Air cooler 2 (Fig.20) is bolted to bracket 8. Bracket 8 is secured by means of bolts 5 to the flange of the upper bow housing of the major accessories drive and is locked by two pins 7.

One end of branch pipe 1 is fastened to the engine frame end face with the aid of bolts 6, and the other end is secured to cooler 2.

Special flanges are bolted through gaskets between branch pipe 3 attached to the cooler and the branch pipe of the turbo-supercharger. This joint is sealed by means of rubber-fabric hose 9 embraced by clip 4 provided with turnbuckles 13.

The elastic joint between branch pipe 3 and the branch pipe of the supercharger volute makes up for the elongation of the entire air pipeline during heating.

The air cooler is of the tubular, double-flow type cooled by sea water.

The cooler heat-exchanging unit consists of flat ribbed pipes 4 (Fig.21). The unit is enclosed in welded housing 3 provided with brass covers 2 and 5 attached to the tube plates of the heat-exchanging unit.

Sea water is delivered through branch pipes made in lower cover 5 and provided with a partition separating the water supply and return sides. Fastened to the partitions are protectors 7. The branch pipes are connected to the pipeline through rubberized-fabric hoses 8 provided with clips 9. The cooler housing lower part is sealed by paronite gasket 9 fitted on special sealing compound "Hermetic" between the housing flange and blank plug 11. Gasket 9 is snapped by means of bolts through spacer 10.

Bracket 6 welded to cooler housing 3 attaches the latter to bracket 8 (Fig.20). Pipe union 1 serves to bleed air from the cooler water cavity.

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Chapter VI

TURBO-SUPERCHARGER

The turbo-supercharger (Fig.22a) supplies the diesel engine working cylinders with air necessary for combustion of fuel in the cylinders and for cleaning the cylinder of combustion products.

The turbo-supercharger is driven by the energy of the diesel engine cylinder exhaust gases. However, the gas turbine power is insufficient for driving the supercharger both at nominal and partial ratings of engine operation and, therefore, additional power is transmitted through the fluid coupling and the minor accessories drive from the engine crankshafts.

The turbo-supercharger unit comprises a single-stage centrifugal supercharger and a single-stage axial reaction gas turbine fitted on one shaft.

The unit is bracketed with its flange to the upper housing of the major accessories drive and is held on a bracket fastened to the lower housing of the drive.

The unit housing consists of supercharger casing and gas turbine casing. The supercharger casing comprises inlet branch pipe 2 (Fig.22b) and volute 1 cast of aluminium alloy. The gas turbine casing includes gas inlet part 11 with branch pipes, and gas outlet part 14, both cast of heat-resistant steel.

The gas flow part of the unit comprises volute 1, vaned diffuser 7 mounted in the volute, inducer 5 and supercharger impeller 6. Volute 1 and vaned diffuser 7 are designed to transform the kinetic energy of air into the energy of pressure. Inducer 5 ensures its shockless coupling with the impeller. The inducer vanes and impeller blades get in contact and form a common blade surface.

Inducer 5 is prevented from rotation by means of two pins, and together with impeller 6 screwed to the sleeve keyed on the rotor shaft it is clamped by fairing 4.

In addition to inlet and outlet part housings 11 and 14, the gas part of the unit includes guide vane (nozzle diaphragm) assembly 12, rotor 19 with blades 13, and seals.

The vanes of guide vane assembly 12 serve for converting the gas potential energy into kinetic energy. Turbine blades 13 convert the kinetic energy of exhaust gases into mechanical work. The blade is provided with a three-forked shank which gets into the rotor disc slots and is riveted there.

Unit rotor 19 is common for the turbine and supercharger. Fairing 4, inducer 5, supercharger impeller 6 and labyrinth seal sleeve 5 are secured on the rotor shaft, while sealing rings 18 are rolled into the shaft. The rotor disc is forged integral with shaft 18.

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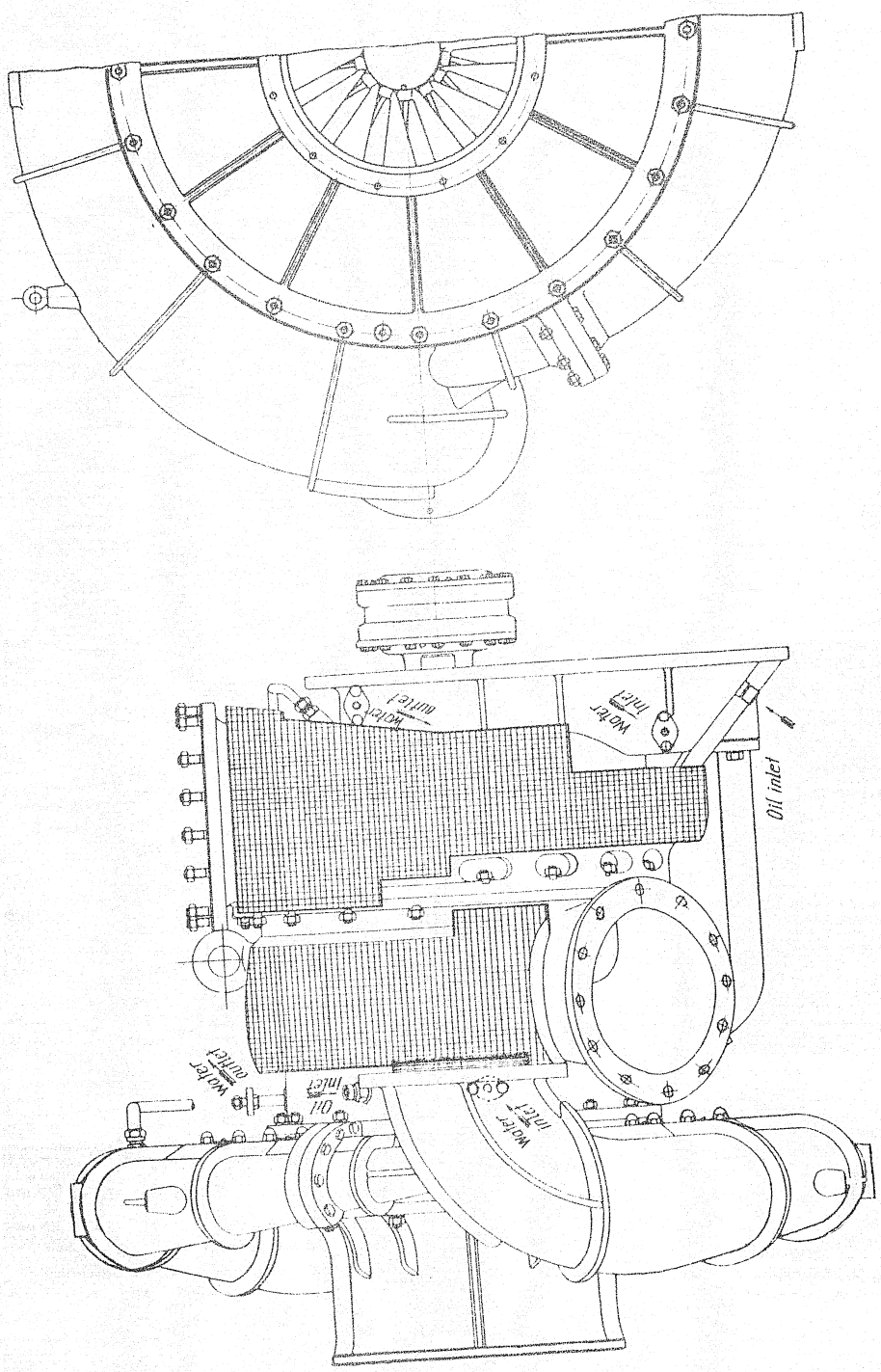

FIG. 22a. TURBO- SUPERCHARGER (GENERAL VIEW)

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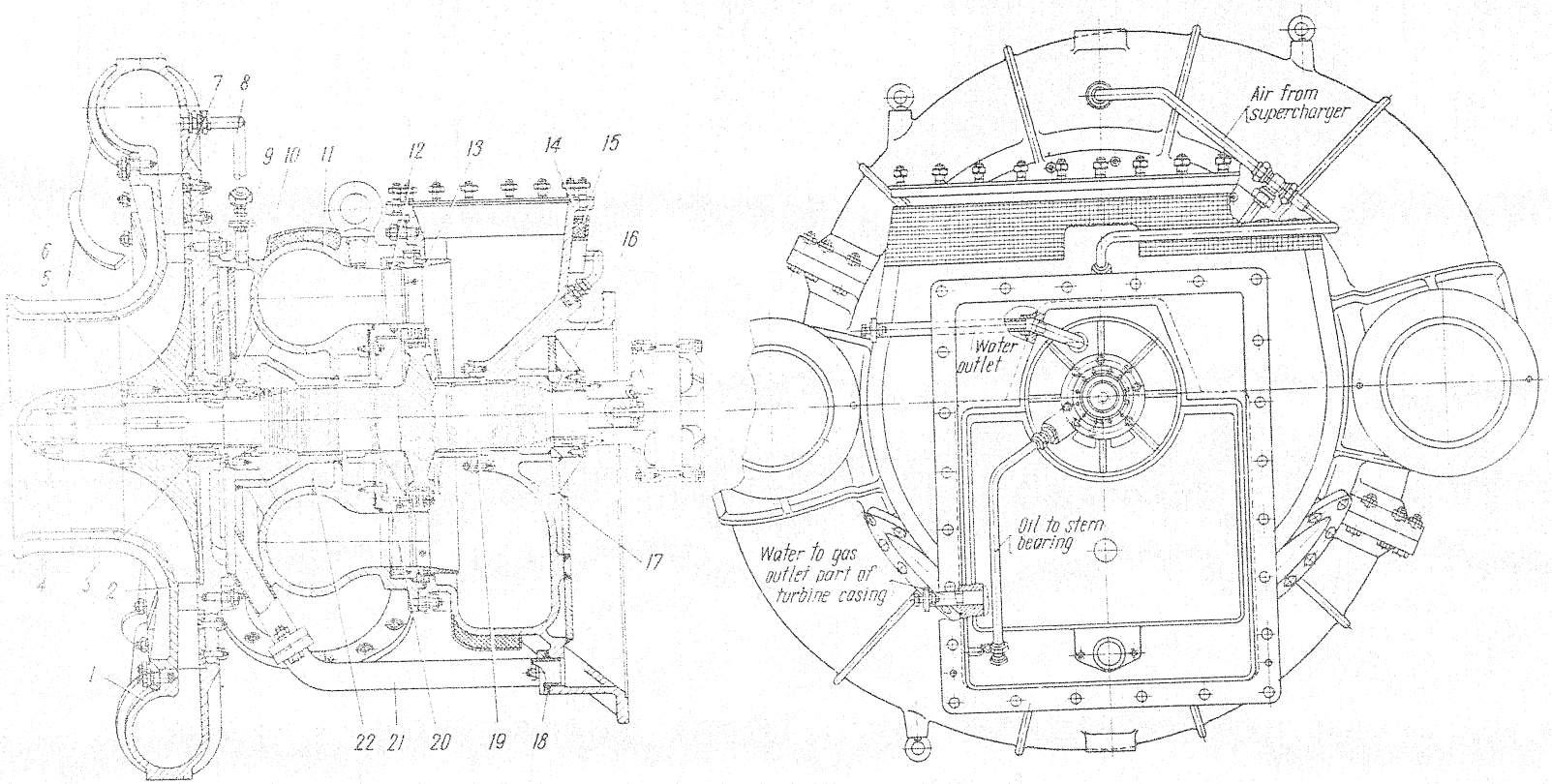

FIG. 22L. TURBO-SUPERCHARGER (LONGITUDINAL SECTION)

1 – supercharger volute; 2 – inlet branch pipe; 3 – labyrinth seal sleeve; 4 – fairing; 5 – inducer; 6 – supercharger impeller; 7 – vaned diffuser; 8 – air pipe; 9 – water return pipe; 10 – supporting-and-thrust bearing; 11 – gas inlet part of turbine casing; 12 – turbine guide vane assembly; 13 – turbine blades; 14 – gas outlet part of turbine casing; 15 – heat insulation; 16 – stern bearing; 17 – cooling cavity; 18 – rubber sealing ring; 19 – rotor; 20 – labyrinth seal; 21 – oil return pipe; 22 – cooling cavity

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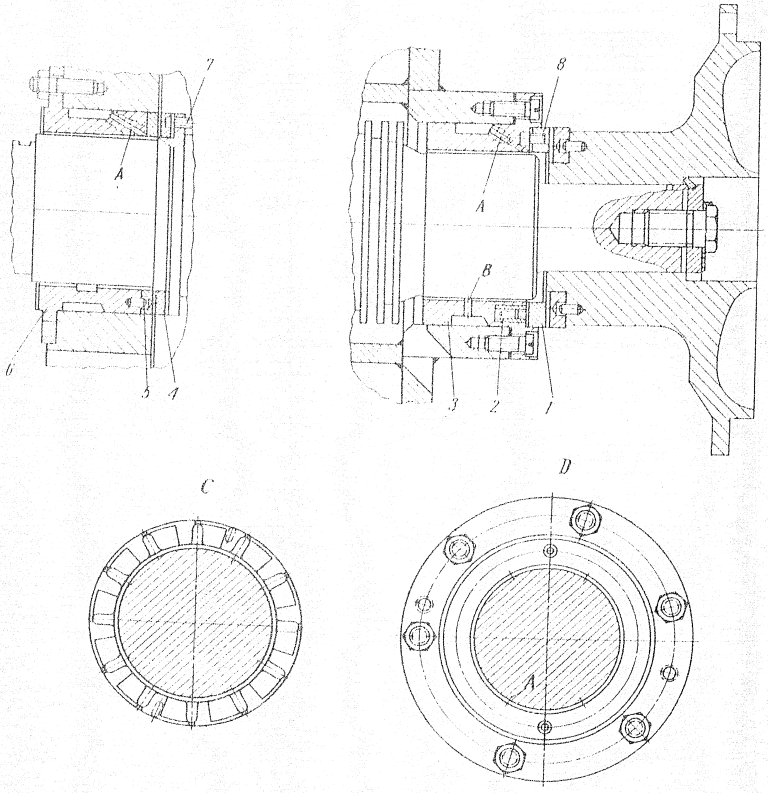

FIG. 23. TURBO-SUPERCHARGER BEARINGS

1 – bronze ring; 2 – bushing with retainer; 3 – bush; 4 – thrust ring; 5 – bronze ring; 6 – bush; 7 – locking screw, 8 – pin; A, B – oil feed drillings. C – view of thrust ring 4; D – view of the thrust end face of bearing 6

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The rotor runs in two supporting-and-thrust sliding friction bearings, namely bow bearing 10 which is the main thrust bearing, and stern bearing 16 which partially relieves the main bearing of axial load.

The bow bearing (Fig.23) is really bronze bush 6 babbit-lined over the working surface and the bow end face. Bush 6 is held to the housing by means of six studs. Smooth bronze ring 5 is attached by two pins to the bush stern side. Running in this ring is case-hardened steel thrust ring 4 secured to the rotor shaft with the aid of two locking screws 7. Two shaped chamfers made on the working surface of ring 4 produce an oil wedge. Radial oil feed drillings B supply oil to the working surface of bush 6, while inclined drillings A and the clearance between the shaft and ring 5 admit oil to thrust ring 4.

The stern bearing is bronze bush 3 babbit-lined over the working surface. Twelve bushings with retainers 2 and springs, which serve as a rest for smooth bronze ring 1 held against rotation by two pins 8, are pressed into the bush from the stern end face. The bronze ring is in contact with the steel case-hardened ring provided with shaped chamfers; the case-hardened ring is pressed on the fluid coupling driven rotor and is kept against rotation by two pins. Supply of lubricant to the stern bearing is similar to the supply of lubricant to the bow bearing, i.e. through radial drillings B and inclined drillings A.

The bearings are lubricated with oil from the diesel engine lubricating system. Oil is fed along external pipes to the pipe unions in the intermediate part of the unit (for the bow bearing) and in the stern part (for the stern bearing), see Fig.22a. Oil is returned from the bow bearing along pipe 21 (Fig.22b) into the stern bearing chamber, whence it flows into the diesel engine frame. Rubber ring 18 ensures sealing of oil return pipe 21.

To prevent overheating of bearings due to heat transfer, fresh water fed from diesel engine cooling system circulates over the turbine walls through circular cooling cavities 17 and 22.

Compressed air fed from volute 1 along pipe 8 into the chambers between the labyrinth seals produces an air seal and thus cools the rotor shaft and reduces leakage of gas through the labyrinth seals.

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Chapter VII

FUEL FEED SYSTEM

FUEL FEED SYSTEM DIAGRAM

The diesel engine fuel system includes: fuel feed pump 3, (Figs 24a, 24b), two filters 5 (one filter for each row of cylinders), high-pressure fuel injection pumps 10, injectors 9, high-pressure pipeline (running from fuel injection pumps to injectors), and low-pressure pipeline.

Fuel feed pump 3, attached to the diesel engine, pumps fuel from service tank 1 and delivers it through filters 5 into pipeline 16, from which it is directed to high-pressure fuel injection pumps 10 along hoses 18. Surplus fuel is returned from pumps 10 back into service tank 1 along hoses 17 and pipeline 15. Constant pressure valves 12 fitted in pipeline 15 maintain constant value of fuel pressure in the fuel feed system of pumps 10, and thus ensure uniform filling of the pumps.

CONSTANT PRESSURE VALVE

The constant pressure valve (Fig. 24c) consists of body 1, nut 6, valve 8, spring 9, adjusting screw 3 with nut 4 and cap 2.

The pressure of fuel lifts valve 8 above its seat, as a result of which the valve by-passes the fuel. Pressure of fuel in the system is ensured by the tension of spring 9 adjusted with the aid of screw 3. Rose-copper gaskets 5 and 7 placed under nuts 6 and 4 prevent leakage of fuel.

The fuel leaking from the injectors is returned along pipes 20 (Fig.24b) into pipe 13, while the fuel leaking from high-pressure pumps 10 gets into pipeline 14 through pipes 19.

From pipes 13 and 14 the contaminated fuel leakage is directed into the drain tank.

Each pipe used to discharge the fuel leaking from pumps 10 carries a non-return valve consisting of body 21, valve 22 and spring 23. The fuel pressure produced in the fuel injection pump housing during the working stroke of the fuel injection pump tappet opens valve 22 and forces the fuel (oil-air mixture) into drain pipeline 15. During the return stroke, the tappet creates rarefaction in the fuel injection pump housing, due to which the oil from the gap between the tappet and the housing, as well as the fuel leaking through the clearance of the plunger couple, are sucked into the pump housing cavity.

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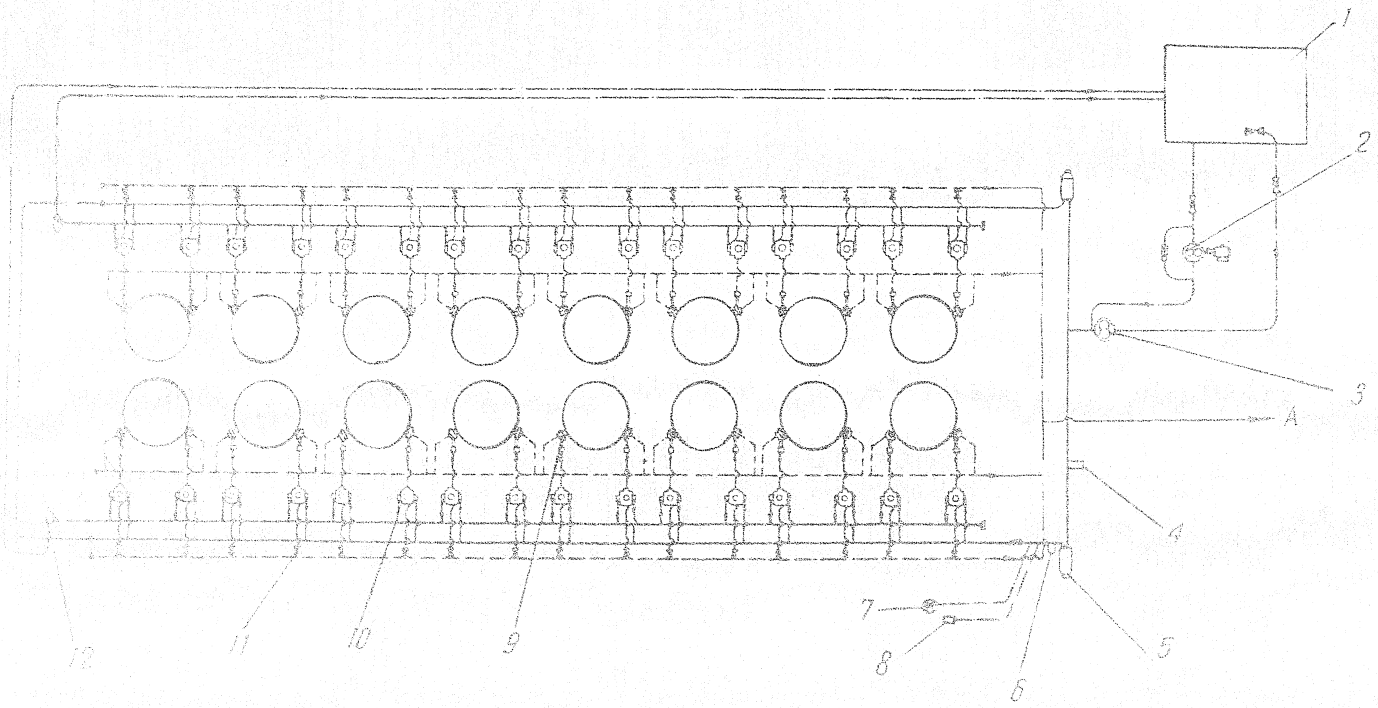

FIG. 24a. FUEL FEED SYSTEM DIAGRAM

1 – service tank; 2 – independent fuel feed pump; 3 – fuel feed pump on diesel engine; 4 – pipe union for attaching the pressure gauge used for periodic measurement of fuel pressure; 5 – fuel filter; 6 – pipe union to attach the pressure gauge used for measuring the fuel pressure downstream of filter; 7 – pressure gauge; 8 – minimum pressure relay sensor; 9 – injector; 10 – high-pressure fuel injection pump; 11 – non-return valve; 12 – constant-pressure valve; A – discharge of dirty fuel

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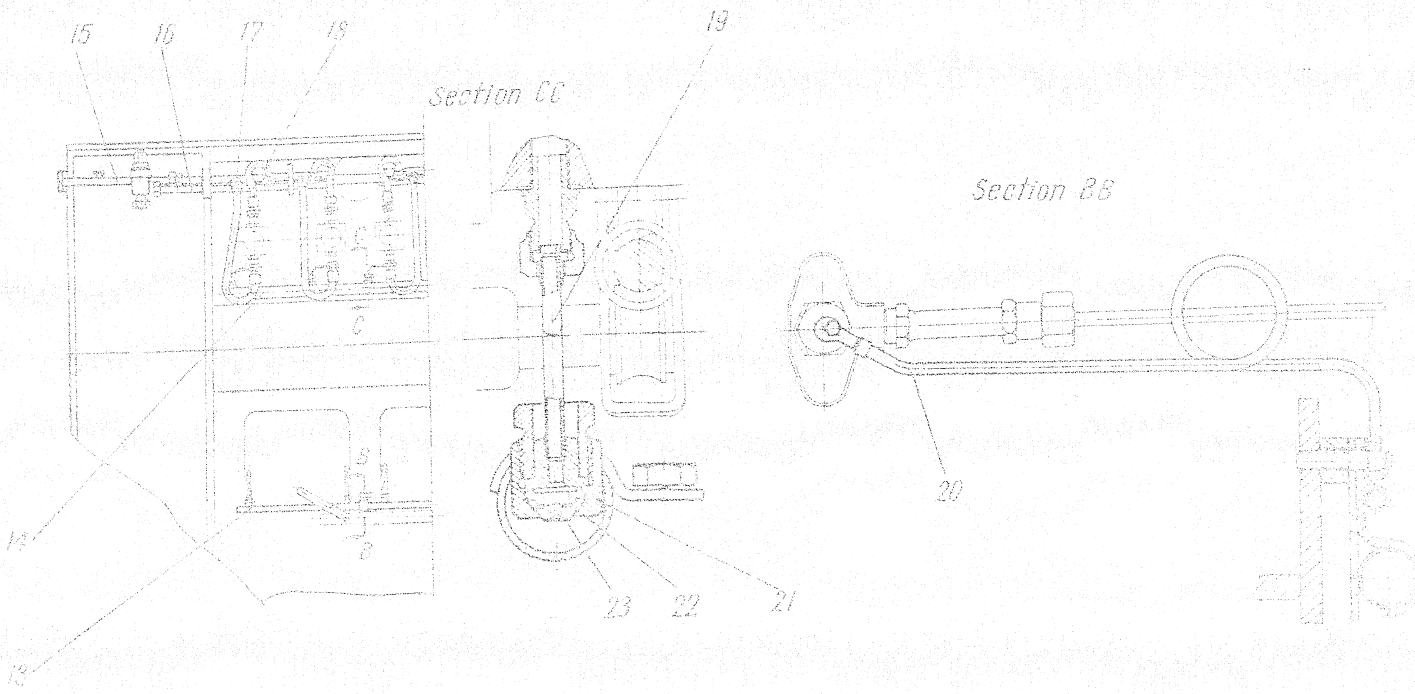

FIG. 245. LOW-PRESSURE PIPELINE

13 – pipe used to drain the fuel leaking from injectors; 14 – pipe used to drain the fuel leaking from high-pressure pumps; 15 – pipe returning surplus fuel from high-pressure pumps; 16 – pipe supplying fuel to high-pressure pumps; 17 – hose returning fuel from high-pressure pumps; 18 – hose supplying fuel to high-pressure pumps; 19 – pipe for fuel leaking from high-pressure pump; 20 – pipe for fuel leaking from injectors; 21 – non-return valve body; 22 – valve; 23 – valve spring

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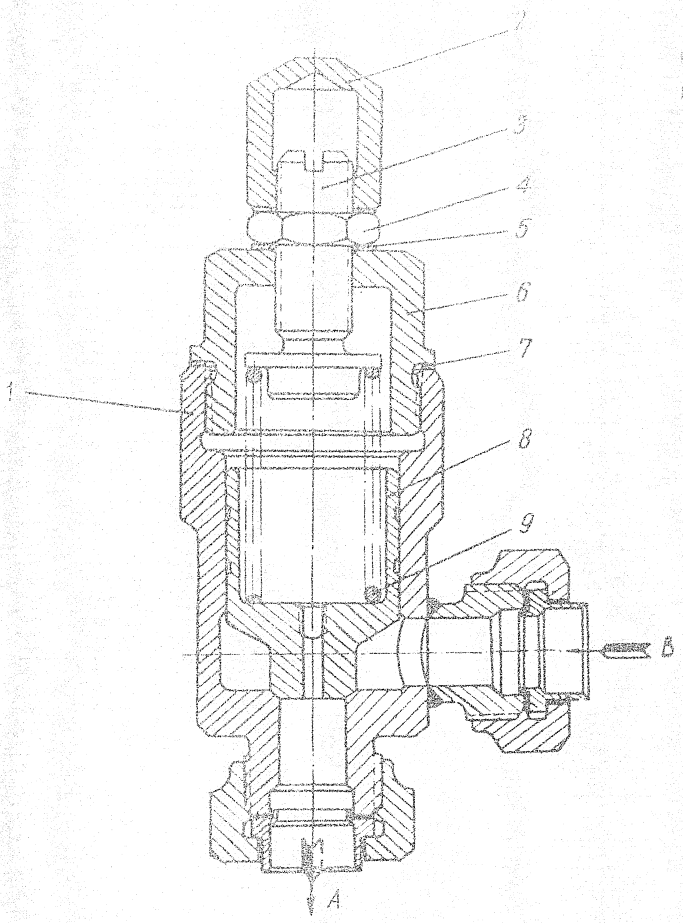

FIG. 24c. CONSTANT PRESSURE VALVE

1 – body; 2 – cap; 3 – adjusting screw; 4 – nut; 5 – gasket; 6 – nut; 7 – gasket; 8 – valve; 9 – spring; A – fuel drain; B – fuel inlet

The pressure of fuel in the pipeline upstream of the high-pressure pumps is measured by means of pressure gauge 7 (Fig.24a).

Besides, the fuel pressure is checked by the signalling system. Minimum fuel pressure relay sensor 8 is also fitted in the pipeline upstream of pumps 10. In addition to pump 3, the ship's system must be provided with independent fuel feed pump 2 to prime through the diesel engine with fuel before starting it. A fuel separator should be also provided in the ship's system.

FUEL FILTER

Model 2TF-5 filter consists of two sections operating in parallel.

Casing 15 (Fig.25) of each section accommodates Model 3TF-5 cambric filtering element 14; the filtering element is a non-detachable unit and should be replaced after its service life is expired.

The filtering elements are fitted on pipes 16 screwed into common cover 7. Casings 15 are secured to the cover with the aid of bolts 10, and the filtering elements are pressed to the cover by springs 9.

Rubber rings 13 and 17 ensure sealing between the filtering element and the pipe.

Fuel goes into the filter through pipe union 6 and cock 8, and occupies the space between casing 15 and filtering element 14. The fuel penetrating through the fabric partition of the filtering element enters pipe 16, whence it is directed via passage 1 and pipe union 5 into the pipeline that feeds the high-pressure pumps.

To bleed the air from each filter section when the fuel system is being primed with fuel, cover 7 is provided with two unions 3 locked by nuts 2.

Cock 8 is designed to change over the filter for washing one of its sections with a counterflow of clean fuel from the other section.

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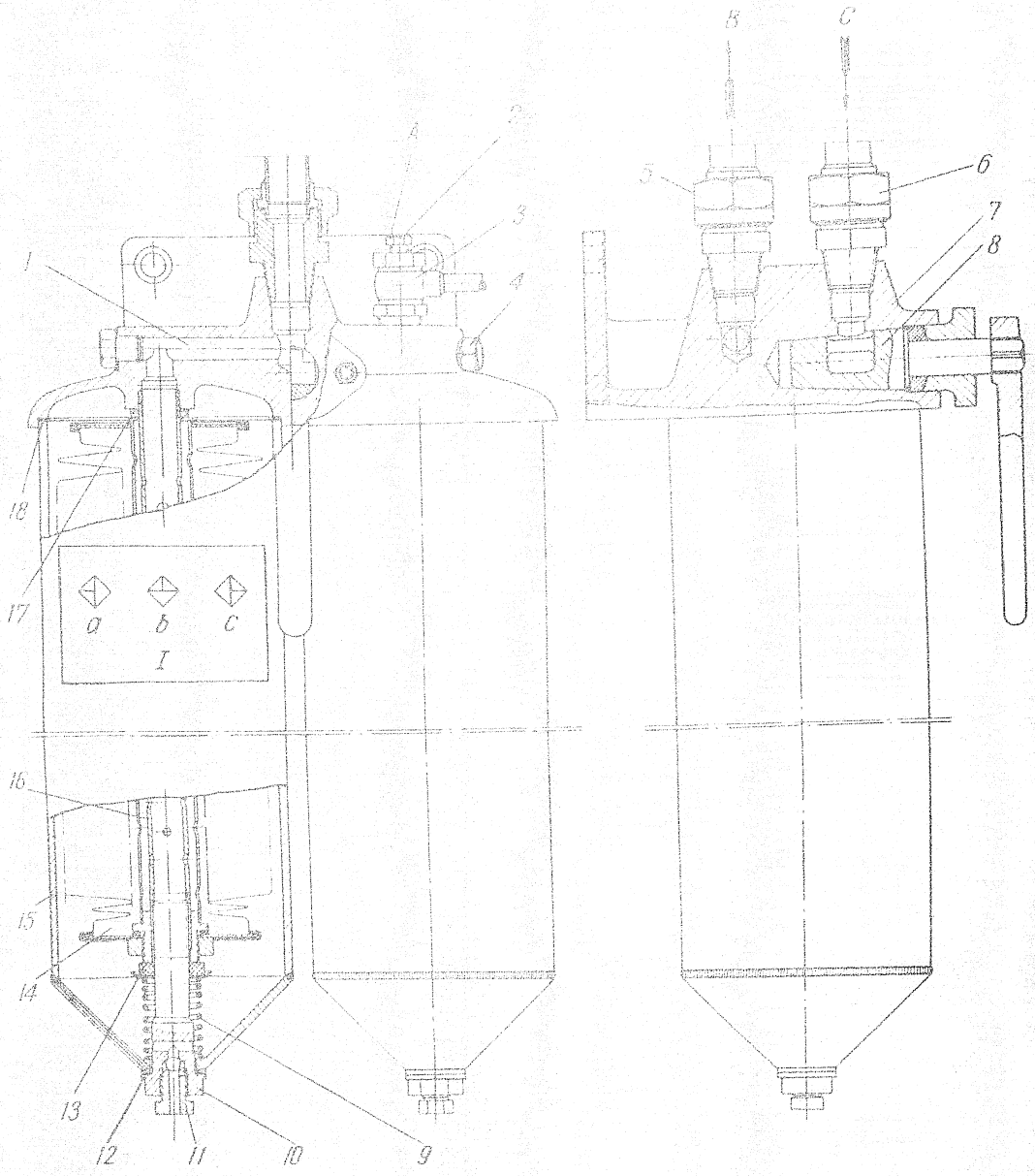

FIG. 25. FUEL FILTER

1 – passage; 2 – bolt; 3 – air outlet pipe union; 4 – plug; 5 – pipe union; 6 – pipe union; 7 – cover; 8 – cock; 9 – spring; 10 – bolt; 11 – drain plug; 12 – gasket; 13 – oil seal; 14 – filtering element; 15 – casing; 16 – pipe; 17 – oil seal; 18 – gasket; A – air outlet; B – fuel outlet; C – fuel inlet; I – position of cock during washing; a – when washing the right-hand section; b – operating position; c – when washing the left-hand section

To drain the dirty fuel after the filter has been washed, provision is made for a drain cock or plug 11.

FUEL FEED PUMP

The gear-driven fuel feed pump supplies fuel to the high-pressure fuel injection pumps and thus maintains circulation in the system. The pump is installed on the stern end face of the main drive and is rotated by the right-hand lower gear of the drive.

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Pump cast-iron housing 5 (Fig. 26) is flanged to the main drive gear bearing cover. The housing has two bores for driving gear 2 and driven gear 1.

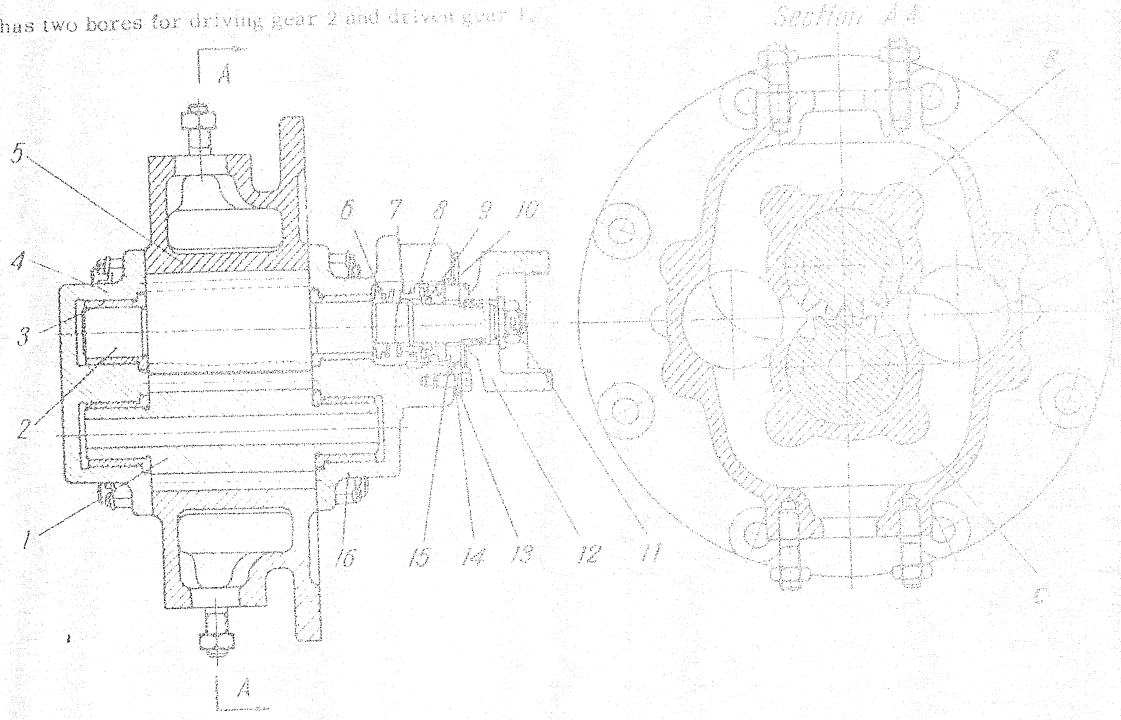

FIG. 26. FUEL FEED PUMP

1 – driven gear; 2 – driving gear; 3 – bronze bushing; 4 – cover; 5 – pump housing; 6 – thrust ring; 7 – spring; 8 – pressure ring; 9 – rubber ring; 10 – graphite ring; 11 – nut; 12 – pump drive coupling; 13 – pressure cover; 14 – rubber ring; 15 – step bearing; 16 – cover

The gear trunnions run in bronze bushings 3 pressed into cover 4.

The housing two passages (lower suction passage C and upper delivery passage D) communicate with two chambers which accommodate guiding spacers B secured by pins.

An end face seal is fitted at the place where the driving gear shaft comes out of cover 16.

Spring 7 mounted between thrust ring 6 and pressure ring 8 presses graphite ring 10 to step bearing 15. Fitted between pressure ring 8 and graphite ring 10 is rubber ring 9 which seals the shaft outer surface. Pressure cover 13 presses rubber ring 14 to step bearing 15 and thus ensures sealing between the shaft and cover 16.

The driven part of pump drive coupling 12 is secured by means of nut 11 to the splined end of the shaft of gear 2.

HIGH-PRESSURE FUEL INJECTION PUMPS

Each working cylinder of the diesel engine is supplied by two separate slide-valve type fuel injection pumps with built-on delivery valves, actuated directly from the cam plates of the camshaft. Each pump is intended for one injector.

The pumps are arranged in two groups along the scavenging air receivers and are fastened to flanges available on the frame sections.

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Pump cast-iron housing 7 (Fig. 27) accommodates a plunger couple consisting of slide-valve-type plunger 8 and plunger sleeve 9. Turning of the plunger sleeve relative to the housing is prevented by screw 2 locked by lead seal 4. The sleeve end face is close-fitted by a delivery valve comprising valve seat 10 and valve proper 11. In case one of the plunger couple parts or the valve unit fails, the couple or the unit must be replaced with their complete sets.

The plunger sleeve and the valve seat are lapped to each other. The valve houses spring 12 which rests with one of its ends against the valve bottom, and with the other end against the end of valve lift limiter 13. Pump head 14 is held to the housing by [illegible] Union nuts 5 provided with nuts 6. The circular cavity between the plunger sleeve portion adjacent to seat 10 and the housing forms the suction chamber. Pipe union 3 supplies fuel to the pump, while pipe union 15 removes surplus fuel.

Toothed bushing 17 meshed with gear rack 1 is loose-fitted on the plunger sleeve. The plunger guide gets freely into the bushing slot, due to which the plunger is free to rotate about its axis together with the bushing, and at the same time it can travel axially.

Screw 28 holds the rack against turning and limits its axial travel.

One end of the rack mounts roller 29 for connection to the control rods, while the opposite end has a threaded hole for the adjusting stop used for determining the rack stroke during installation of pump on diesel engine. Retainer 18 prevents axial travel of bushing 17 and serves as a rest for plunger spring 19. The other end of the spring bears against retainer 21 fitted on the plunger.

Tappet 22 rests with its end face against the plunger and the spring retainer. Translatory motion is imparted to the tappet by the cam plate through roller 23 which rotates freely on needle rollers 24 of pin 25.

One end of the roller pin enters the pump housing slot and thus prevents the tappet from rotating about its axis.

To prevent the tappet and other parts from falling out when the pump is not mounted on the diesel engine, the housing outer surface has a circular groove with elastic ring 30 in it.

Pin 26 getting into the diesel engine frame seat ensures parallel alignment between the tappet roller pin and the camshaft axis.

Sealing of the pump during its installation on the diesel engine is ensured by rubber sealing ring 20. The fuel leaking through the gap between the plunger and the sleeve is discharged from the pump housing through hole 27.

The tappet, roller, needle bearing and pin are lubricated with oil fed to the tappet surface through a funnel-shaped hole made in the pump housing. From the tappet surface the oil flows along two drilled passages and lubricates the needle bearing, roller and pin.

Adjustment of pump with regard to the fuel injection advance angle is done by varying the thickness of the set of shims 31. Different value of fuel feed (from zero to maximum) is obtained by turning the plunger relative to its sleeve with simultaneous travel of the rack. The inclined cuts available on the plunger change the moment of opening and closing of the sleeve side holes, i.e. they change the start and end of fuel injection and, consequently, the advance angle and the amount of fuel feed.

To eliminate repeated fuel injections, provision is made for relieving the delivery pipeline of high residual pressure on the account of the relieving stroke of the delivery valve. The relieving stroke begins at the moment when the relieving collar helix aligns with the seat guiding hole helix, and stops at the moment when the valve enters its seat.

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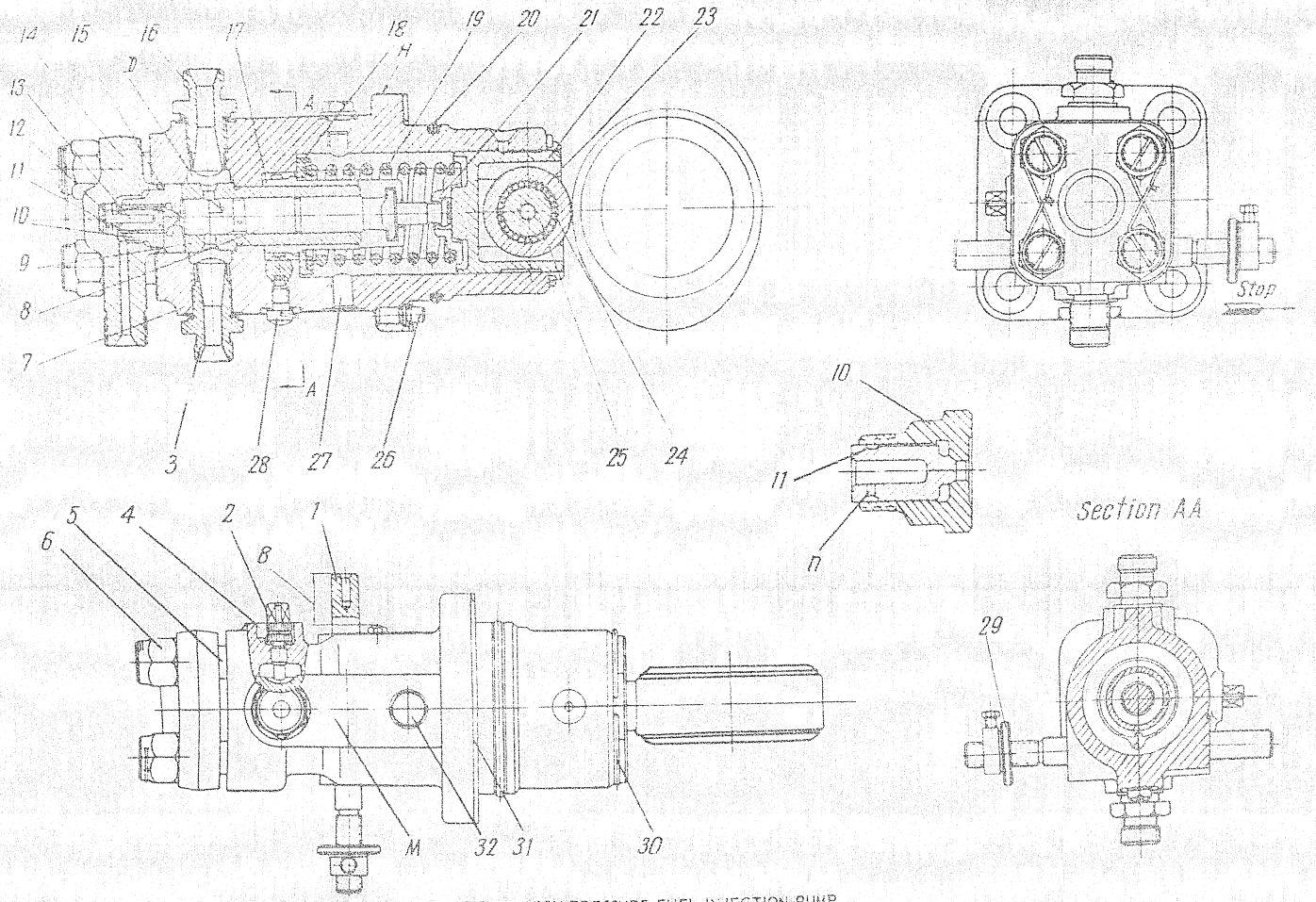

FIG. 27. HIGH-PRESSURE FUEL INJECTION PUMP

1 – gear rack; 2 – screw; 3 – fuel feed pipe union; 4 – seal; 5 – stud; 6 – nut; 7 – pump housing; 8 – plunger; 9 – plunger sleeve; 10 – delivery valve seat; 11 – delivery valve; 12 – valve spring; 13 – valve lift limiter; 14 – pump head; 15 – sealing ring; 16 – fuel outlet pipe union; 17 – toothed bushing; 18 – spring stationary retainer; 19 – plunger spring; 20 – rubber sealing ring; 21 – spring retainer; 22 – tappet; 23 – tappet roller; 24 – needle roller; 25 – roller pin; 26 – pin; 27 – leakage drain hole; 28 – screw; 29 – rack roller; 30 – elastic ring; 31 – set of shims; 32 – plug; B – value of rack stroke; D – pump suction cavity; M – surface on which the distance between the cam plate pitch circle and the flange (as obtained during adjustment on the stand) is punched; H – place for stamping the pump number; n – delivery valve correcting hole

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Delivery valve 11 is provided with correcting hole "n" which ensures steady operation of the diesel engine at idle running.

INJECTOR

The diesel engine injectors are of the enclosed type and are mounted radially in the pipe unions of the working cylinder sleeve. The angle between the injector axes makes up 120°. According to their arrangement on the sleeve, the injectors fall into left-hand and right-hand, differing from each other only in the location of the spraying orifices in the nozzles. Injectors marked with LH (ЛЕВ.) are mounted on the bow side of the left-hand row sleeves and on the stern side of the right-hand row; injectors marked with RH (ПРАВ.) are installed on the bow side of the right-hand row sleeves and on the stern side of the left-hand row.

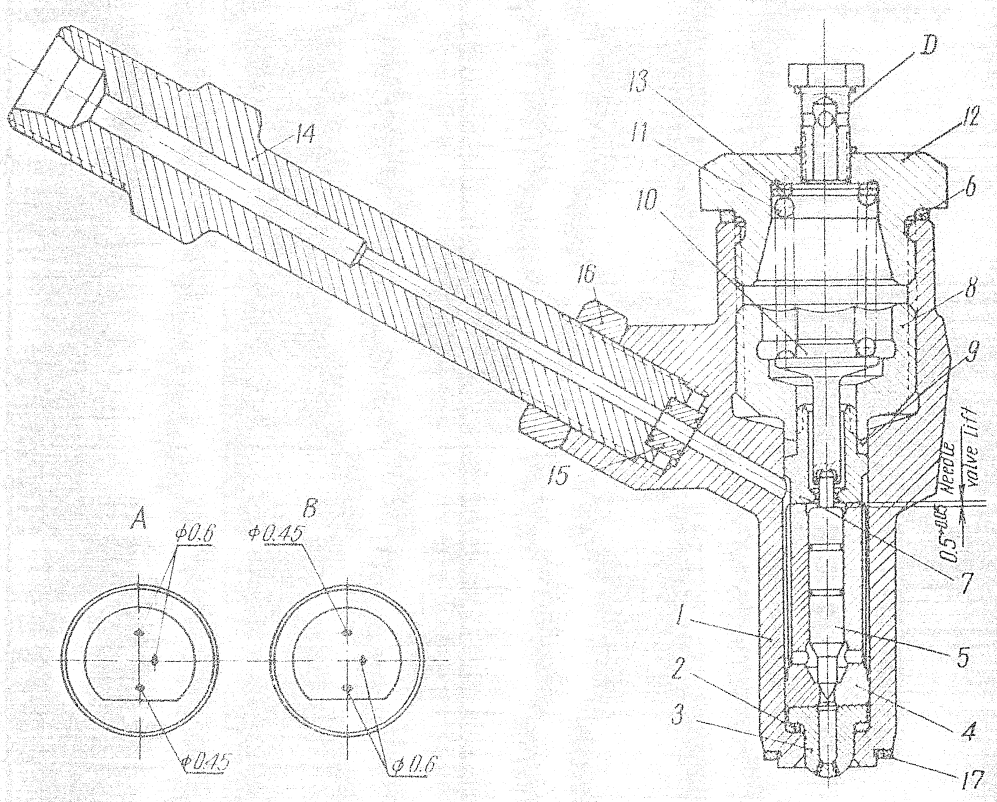

FIG. 28. INJECTOR

1 – injector body; 2 – gasket; 3 – nozzle; 4 – needle valve guide; 5 – needle valve; 6 – gasket; 7 – needle valve lift limiter; 8 – pressure nut; 9 – textolite ring; 10 – tappet; 11 – spring; 12 – nut; 13 – set of shims; 14 – fuel supply pipe union; 15 – ring; 16 – nut; 17 – gasket; A – nozzle of left-hand injector; B – nozzle of right-hand injector; D – leakage drain pipe union

Nozzle 3 (Fig. 28), needle valve guide 4 with needle valve 5, and needle valve lift limiter 7 are mounted on soft steel gasket 2 inside injector steel body 1. All these parts are secured in the body by pressure nut 8 through textolite ring 9 which ensures sealing of the high-pressure fuel cavity.

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The joint faces of the nozzle, guides and needle valve lift limiter are thoroughly lapped to size on a surface plate to ensure necessary tightness.

The taper surfaces of the guide and needle valve are also fitted to size by lapping. The needle valve guide and the needle valve are to be replaced only by their complete set.

The needle valve lift is determined by the gap between the end faces of the needle valve and its lift limiter; the gap must be within 0.5 to 0.55 mm. The injector needle valve is loaded through carrier 10 by spring 11, whose tension is ensured by nut 12 and adjusted by selecting proper thickness of the set of shims 13 and 6. Shim 6 serves at the same time to lock nut 12.

Fuel is fed to the injector through pipe union 14. Ring 15 and nut 16 ensure sealing of the pipe union.

Sealing of the injector in the working cylinder pipe union against escape of gases is obtained by upsetting copper gasket 17.

The fuel leaking through the gap between the guide and the needle valve is drained through the hole available in nut 12.

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Chapter VIII

LUBRICATING SYSTEM

The diesel engine lubricating system includes:

(a) external circuit designed to filter and cool the circulating oil, and also to heat, prime and scavenge the oil when preparing the diesel engine for starting. The pipelines of this circuit are located beyond the engine;

(b) internal circuit supplying oil to the respective units and parts of the diesel engine. The pipelines of this circuit are inside the engine.

EXTERNAL CIRCUIT

The external circuit (Fig.29) falls into:

(a) main circuit consisting of a delivery and a scavenging lines, in which circulation of oil is ensured by a double-section gear-driven oil pump mounted on the diesel engine;

(b) auxiliary circuit in which circulation of oil is ensured by independent electric pumps and oil separator pump.

External Main Circuit

Scavenging section 4 of the double-section oil pump takes oil from the diesel engine sump along pipe 9 and directs it into circulating tank 13 through filter 7 and cooler 8. The pipeline running between the pumps and filter is fitted with distance thermometers and a temperature relay sensor, which check the engine oil outlet temperature.

As soon as the oil temperature exceeds the permissible value, the temperature relay sensor sends an impuls which actuates the warning signalling system.

Adjustment of oil temperature is performed automatically by changing the amount of sea water flowing through cooler 8. Depending on the cooler oil outlet temperature, thermoregulator control unit 9 sends a respective impuls to the thermoregulator pneumatic regulating slide valve (not shown in the diagram) which distributes the flow of sea water to the cooler and past it, to the by-pass line. When the pressure in the system rises above permissible value, by-pass valve 6 directs part of oil past the filter and cooler right into the circulating tank.

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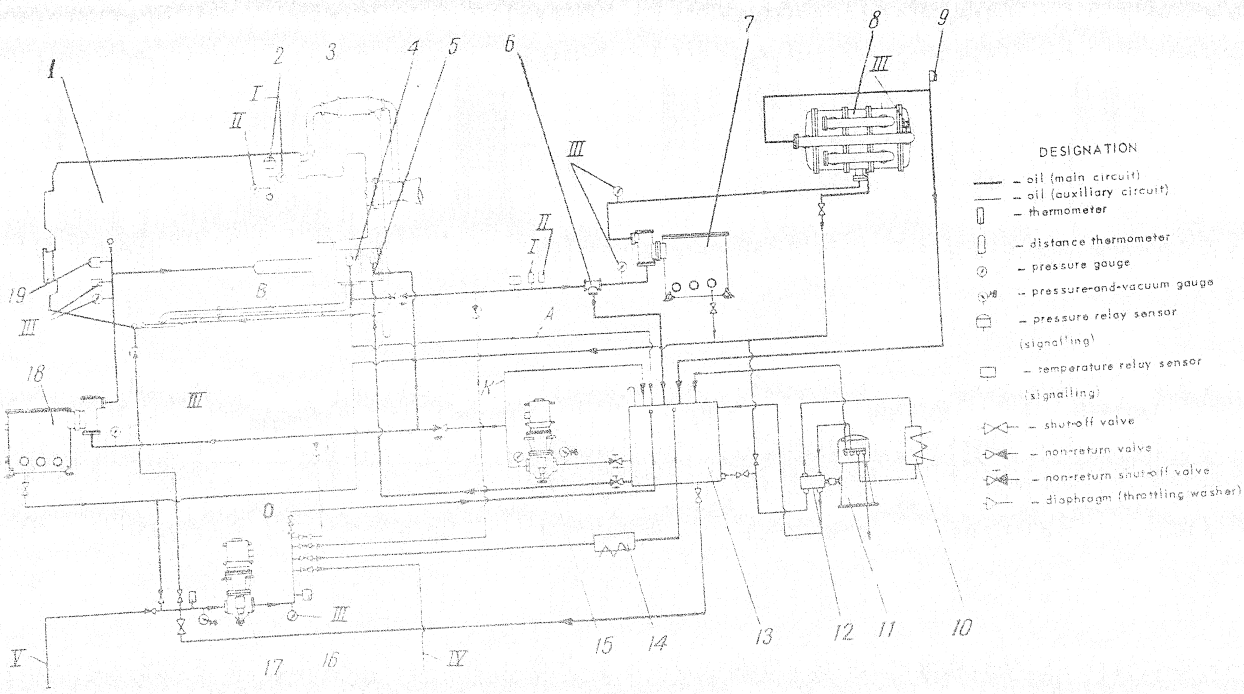

FIG. 29. LUBRICATING SYSTEM EXTERNAL CIRCUIT

1 – diesel engine; 2 – start-permitting relay; 3 – oil separator; 4 – pump scavenging section; 5 – pump delivery section; 6 – by-pass valve; 7 – oil filter; 8 – oil cooler; 9 – thermoregulator control unit; 10 – oil heater; 11 – oil separator; 12 – separator pump; 13 – circulating tank; 14 – oil heater; 15 – independent electric oil pump (priming); 16 – scavenging pressure relay; 17 – independent electric oil pump (scavenging); 18 – oil filter; 19 – minimum pressure relay; A – air outlet pipe; B – oil outlet pipe; D – valve for adjusting the pressure during heating of oil; K – pipe returning part of oil into tank; I – to the remote control board; II – to diesel engine instrument board; III – local control; IV – oil scavenging; V – oil supply

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To ensure normal operation of the oil sump in the section, provision is made for air outlet pipe A which should be kept free to prevent accumulation of oil in it after the diesel engine is stopped.

Pump delivery section 5 sucks oil from tank 13 and supplies it to the diesel engine through filter 16.

Oil is fed to the engine frame sleeve port (from aft side) and to the drive for major accessories (from both sides). Supply of oil to the diesel engine frame may be exercised from any side.

A foot-valve must be fitted to the suction pipe of pump delivery section 5.

Oil pressure gauge, thermometer, pressure minimum pressure relay 19 are mounted at the engine oil inlet side.

The supply chamber of the closed cycle water-cooled cam shaft carries a T-piece for the pressure gauges and engine start permitting relay 2.

Minimum pressure relay 19 sends a signal to the signalling system as soon as the oil pressure drops down below the permissible value.

When the engine is being primed through with oil, start-permitting relay 2 sends a signal to the signalling system as soon as the pressure in the inner oil system reaches the required value.

External Auxiliary Circuit

Independent electric oil pump 15 is designed only for priming the diesel engine with oil in compliance with the following circuit: tank 13 - pump 15 - filter 16 - diesel engine 1.

The purpose of independent electric oil pump 17 is to:

a) force the oil from the diesel engine sump into circulating tank 13;

b) force the oil from the diesel engine sump into circulating tank 13 through filter 7 and cooler 8 on the system scavenging line (for heating the filter and cooler);

c) prime clean oil into the tank;

d) remove the waste oil from the diesel engine, tank and system;

e) prime through the diesel engine with oil (when independent pump 15 is inoperative).

Since both independent pumps are of the same capacity, the guaranteed amount of oil scavenged by pump 17 from the diesel engine sump is ensured by pipe K through which part of oil delivered by pump 15 to the diesel engine is returned into the tank.

Both independent pumps are started by means of the (common) starting button. The pump control system allows to carry out separate starting of the pumps as well.

If oil pressure is produced in the pipeline downstream of scavenging pump 17, pressure relay 16 issues a signal about pump operation (yellow lamp comes up).

Separator pump 12 is designed to feed oil to separator 11 from the system (during diesel engine operation only), or from tank 13. In both cases, the oil may be delivered either heated, or without heating it in oil heater 10.

INTERNAL CIRCUIT

The circuit diagram (Fig. 30) shows the main pipelines which supply oil to separate units. The flow path of oil inside the units is indicated in the descriptions of respective units.

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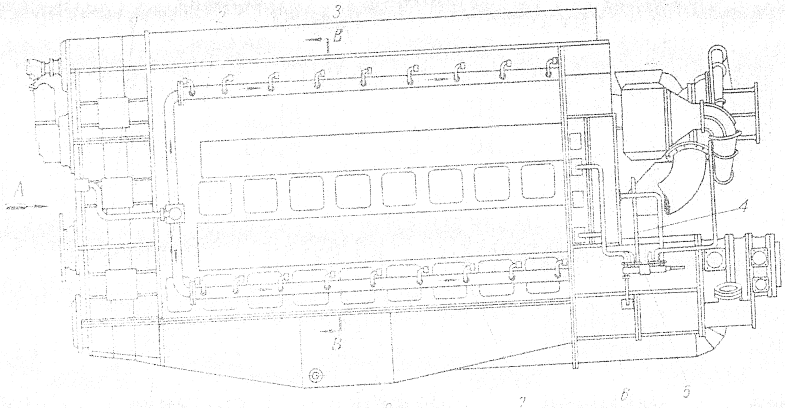
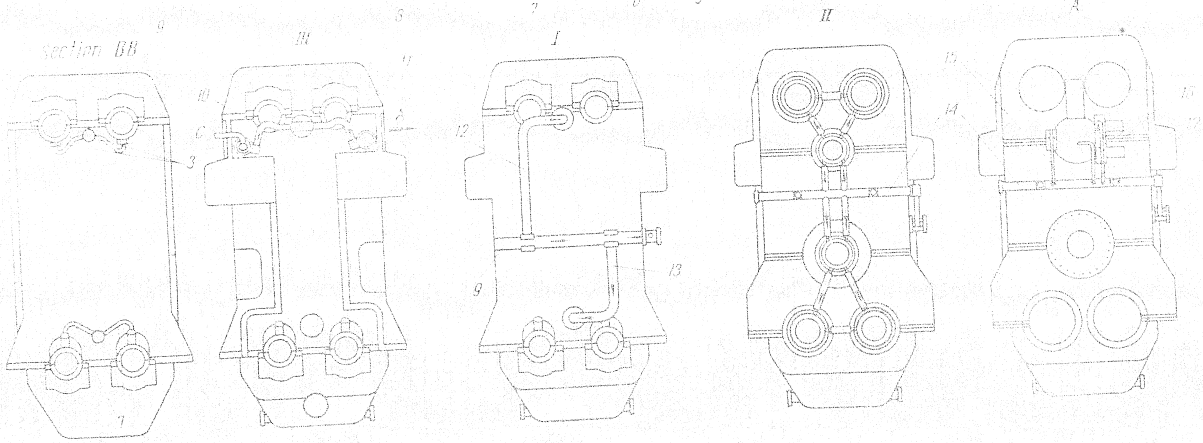


FIG. 30. MAIN PIPELINES OF LUBRICATING SYSTEM INTERNAL CIRCUIT

1 – main drive oil feed pipe; 2 – pipe supplying oil to bearings of upper crankshafts; 3 – pipe running to bearing; 4 – turbo-supercharger oil feed pipe; 5 – supply of oil to the distributing manifold on the drive for major accessories; 6 – pipe running from diesel engine sump to oil pump scavenging section; 7 – pipe running to bearing; 8 – pipe supplying oil to bearings of lower crankshafts; 9 – supply of oil to engine; 10, 11 – camshaft oil feed pipes; 12, 13 – feed pipes; 14 – stern lateral pipe of main drive; 15, 16, 17 – pipes supplying oil to minor accessories; I – view from stern (with main drive removed); II – view A (with drive for minor accessories removed); III – view from bow (with drive for major accessories removed); C – union for measuring the oil pressure in camshaft supply channel



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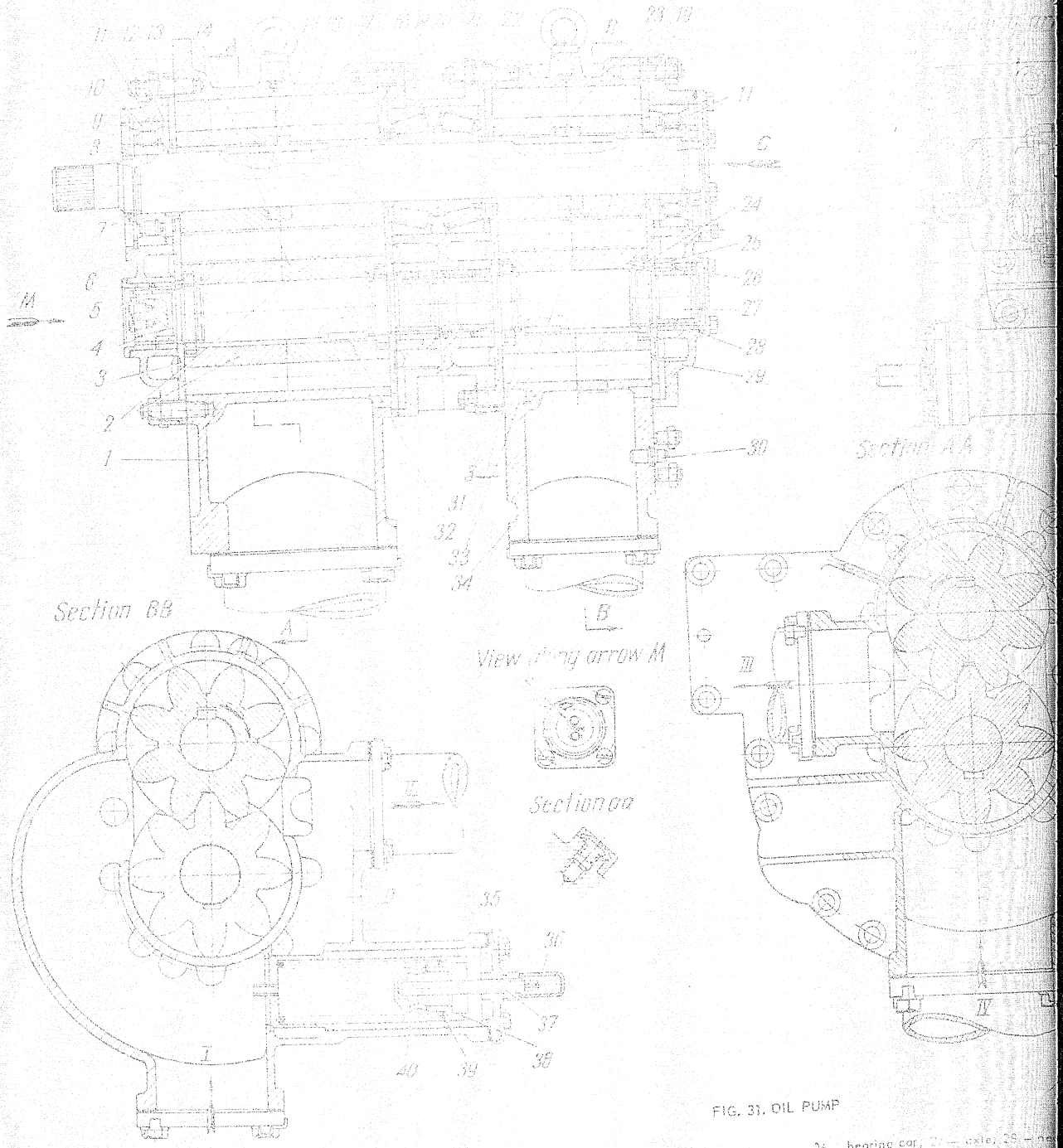

FIG. 31. OIL PUMP

1 – pump scavenging section; 2 – [illegible] section double-helical gear; 3 – sealing partition; 4 – axle; 5 – thrust [illegible]; 6 – [illegible] nut; 7 – tab washer; 8 – elastic ring; 10 – radial roller bearing; 11 – [illegible] scavenging section cover; 14 – right-hand section of pump scavenging section; 15 – [illegible]; 16 – housing of centre bearings; 18 – sealing partition; 19 – taper roller bearing; 21 and 22 – spacing rings; 23 – right-hand section of pump delivery section double-helical gear; 24 – screw; 25 – nut; 26 – bearing cap; 27 – axle; 28 – [illegible] ring; 32 – key; 33 – left-hand section; 35 – valve housing cap; 36 – [illegible] 40 – by-pass valve; 41 – plug; 42 – [illegible] diesel engine; III – [illegible] tank; IV – [illegible]

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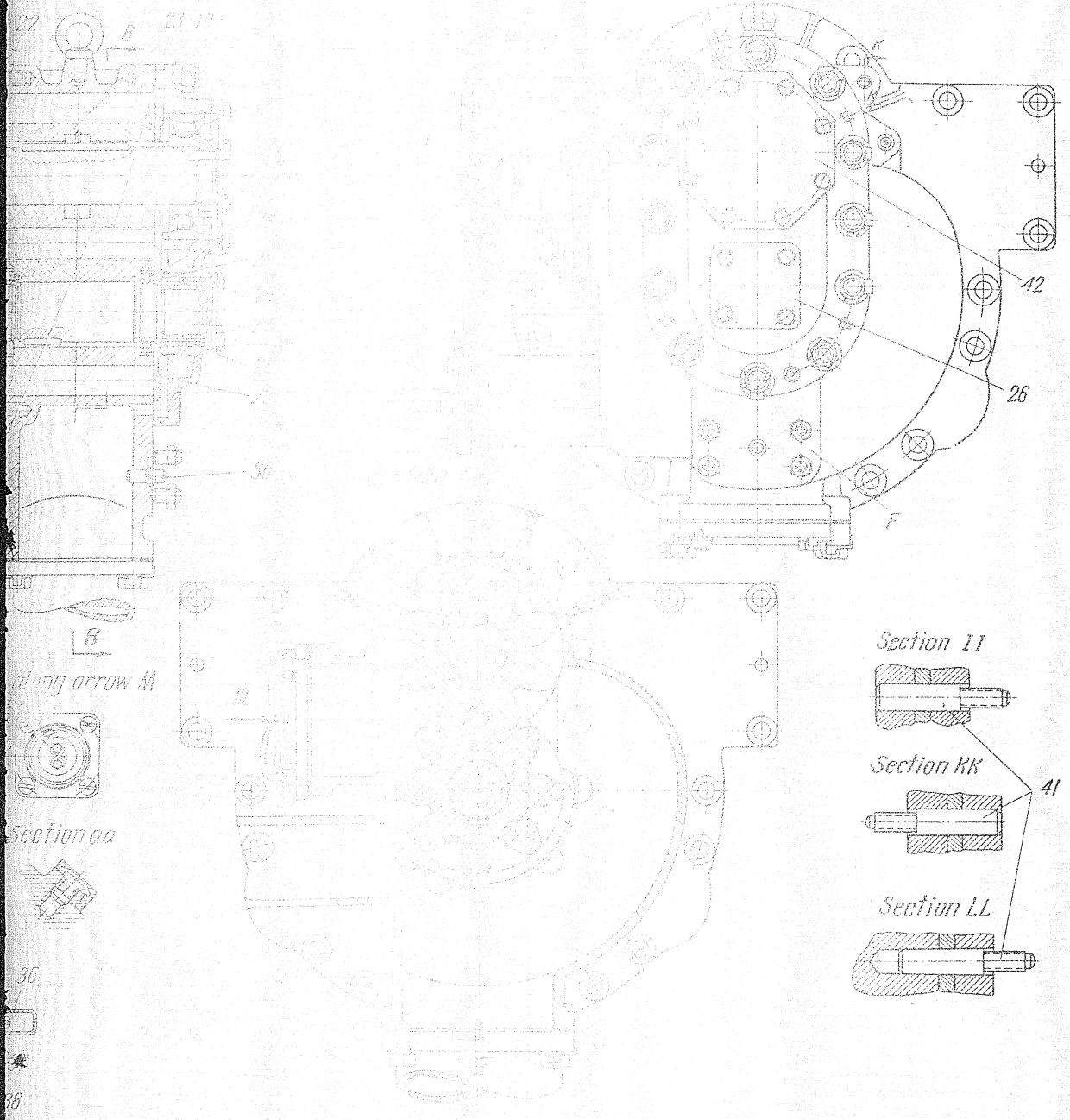

FIG. 31. OIL PUMP

...section double-helical gear; ... nut; 8 – tab washer, 9 – elastic ...tenging section cover; 14 – right ...16 – key; 17 – spacing ring; ...r bearing; 21 and 22 – spacing ...gear; 24 – screw; 25 – nut; ... – delivery section cover; 30 – pin; 31 – spacing ... delivery section double-helical gear; 34 – delivery ... adjusting screw; 38 – valve disc; 39 – spring; ... – flanges; I – from tank; II – to ...

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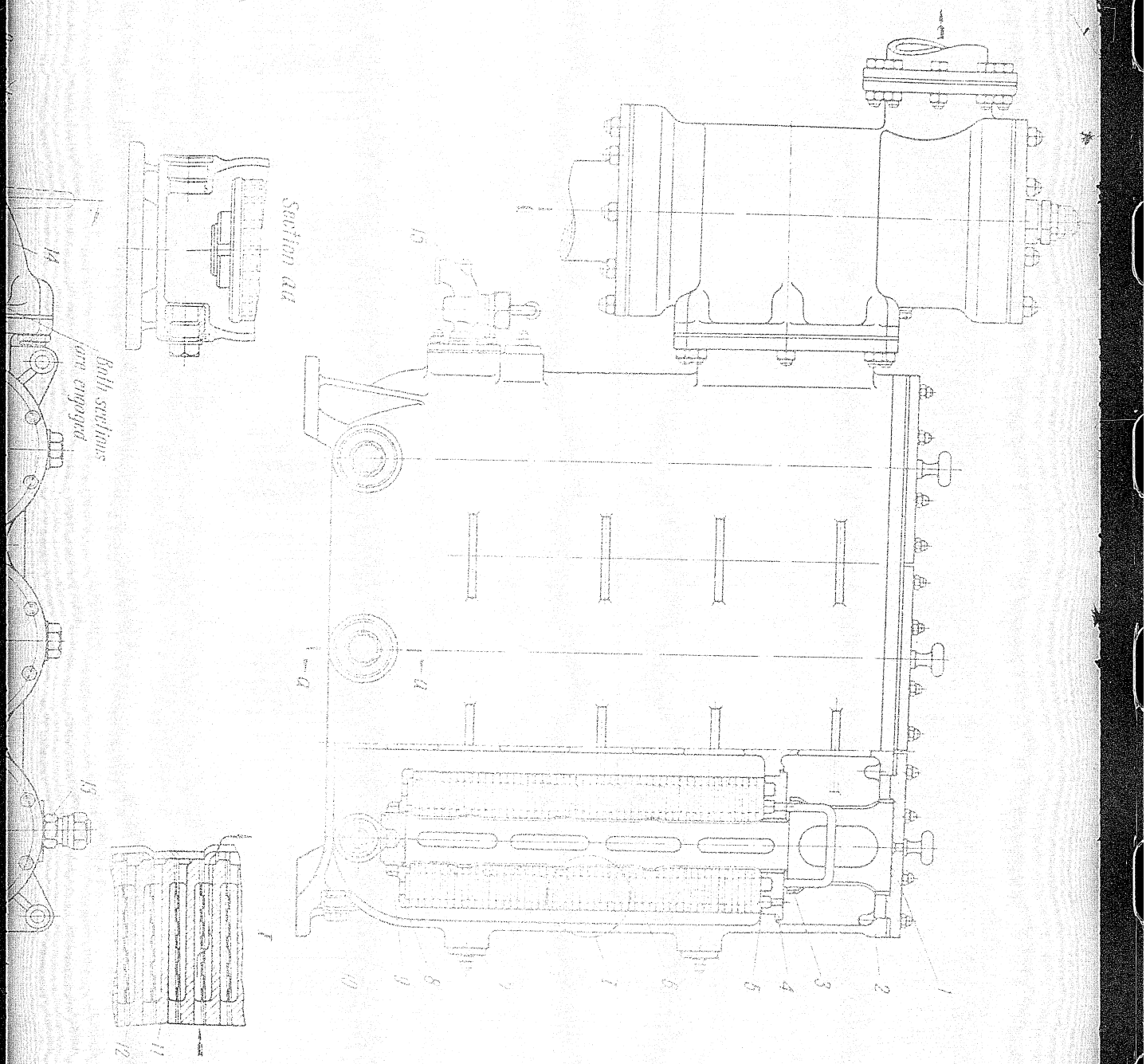

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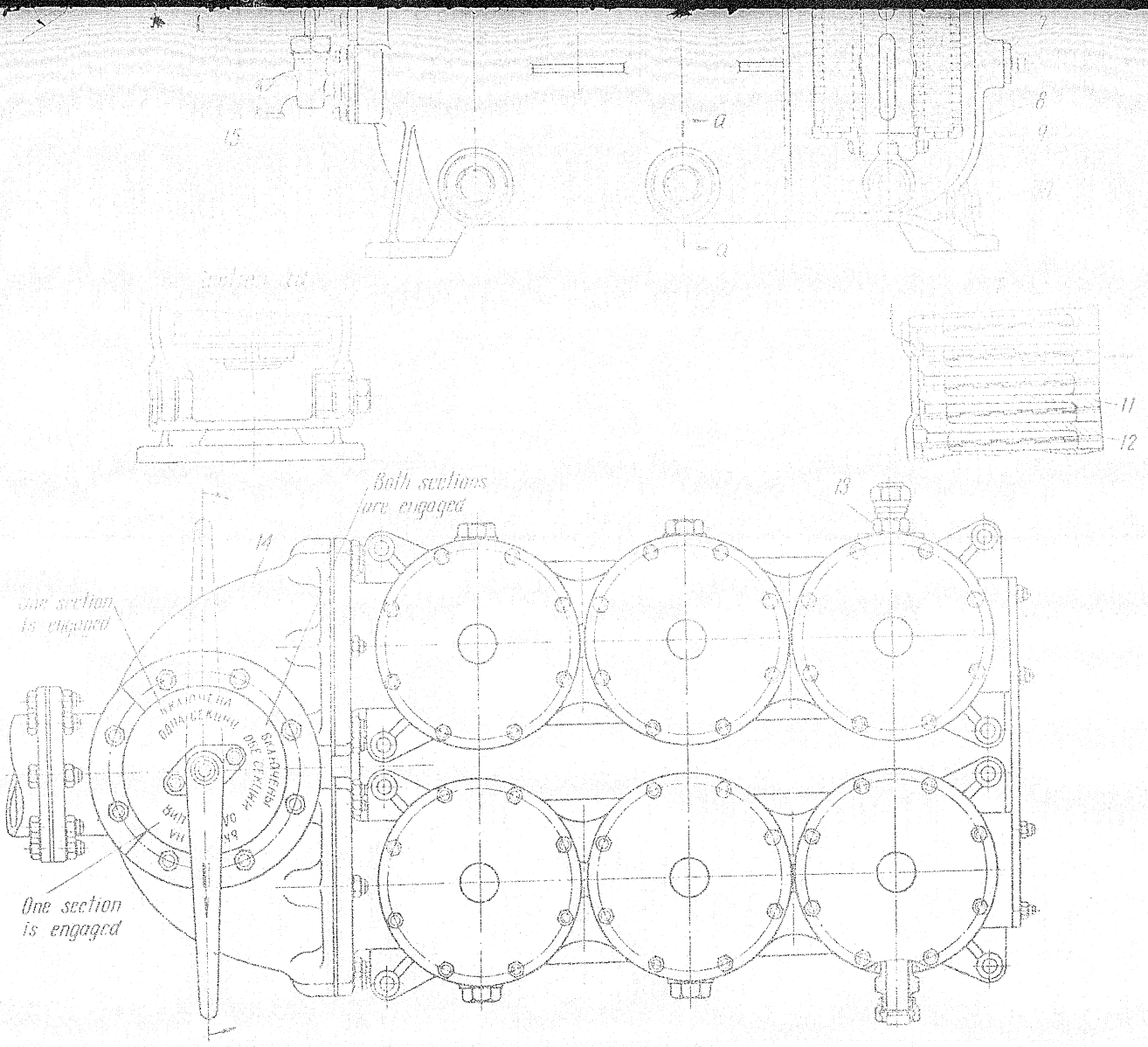

FIG. 32. OIL FILTER

1 – cover; 2 – filter casing; 3 – limiting pipe; 4 – upper disc of filtering cartridge; 5 – cartridge pipe; 6 – filtering cartridge; 7 – strip; 8 – lower disc; 9 – nut; 10 – drain plug; 11 – diaphragm; 12 – filtering screen; 13 – pipe union; 14 – gate; 15 – cock

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Oil is fed to the diesel engine at three points, into frame lateral pipe 9 and into two oil distributing manifolds 5 (on both sides of the diesel engine) of the major accessories drive. From these points the oil is delivered along pipes to the diesel engine units and parts.

Main drive oil feed pipe 1 is mounted on the same side as the diesel engine oil feed pipe is.

From lateral pipe 9 the oil flows along pipes 12 and 13 into pipes 2 and 8 which runs lengthwise the entire engine. The oil from pipes 2 and 8 is fed to the drillings of the frame beds through pipes 3 and 7, and to the camshafts through pipes 10 and 11.

From the bed drillings the oil gets to the crankshaft bearings, then it runs along the shaft drillings to the crank bearings, and further it flows through the connecting rod drillings to the end bearings and to cool the pistons. Waste oil is drained from the pistons and bearings into the diesel engine sump, whence it is sucked in by the pump along pipe 6.

The oil fed through pipe 1 to the main drive gets distributed along the internal pipeline to lubricate the bearings and gears of the drive (see view along arrow A). The waste oil from the main drive sump flows into the diesel engine frame sump.

Stern lateral pipe 14 of the main drive supplies oil through pipes 15, 16 and 17 to lubricate the minor accessories drive.

From oil distributing manifolds 5 the oil is directed along separate pipes to lubricate the bearings and gears of both stages of the major accessories drive, and along pipe 4 it is fed to the turbosupercharger (see also Fig.13c). Waste oil runs down into the lower housing of the major accessories drive, whence it is drained into the diesel engine sump.

OIL PUMP

The double-section gear-driven oil pump with scavenging section 1 (Fig.31) and delivery section 34 is installed on the bow end face of the major accessories drive and is rotated by the drive gear through a splined coupling.

The pump housings are cast of iron. Housing 18 of centre bearings is located between the pump housings. Covers 13 and 29 close the pump section housings on the end faces. The pump parts are centered with each other by means of taper pins 41.

The pump is fastened with its flange E to the drive for major accessories.

The housings of both sections are provided with bores of equal diameter for two pairs of double-helical gears, and are closed by sealing partitions 3 and 19 from the end faces.

The centre bearing housing and the covers accommodate antifriction bearings for the shaft and the axle of the pump. Each of the pump double-helical gears consists of two cast-iron sections.

The teeth of the mating gear sections are cut in different directions. The gear sections of the pump scavenging section are wider than those of the pump delivery section.

The pump driving gears are held to shaft 15 by keys 16 and are tightened up on the shaft together with the inner races of roller bearings 10 and 20 and with spacing rings 11, 17 and 22 by means of nuts 7 provided with tab washers 8.

The double taper roller bearing serves as the oil pump thrust bearing. Axial play of roller bearing 20 is ensured by changing the thickness of ring 21. The necessary end face clearances between the gears and the respective sealing partitions are obtained by varying the thickness of spacing rings 17 and 22. The outer races of roller bearings 10 are held in place by spacing rings 12 and elastic rings 9.

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The driven gears are secured on axles 4 and 27 with the aid of nuts 25 locked by screws 24. One of the sections (14 and 33) of each of the driven gears is held to its axle by key 32. The axles of the driven gears run in double needle bearings 28 whose inner races are pressed to the axle shoulders by thrust washers 5. The outer races of bearings 28 are loose-fitted between the sealing partitions and the shoulders of caps 6 and 26 (for outer bearings), or spacing ring 31 (for inner bearings). The clearances are obtained by varying the thickness of a gasket placed under caps 6 and 26, and also the thickness of ring 31.

By-pass valve 40 built into the pump delivery section serves for maintaining the pressure in the delivery pipeline by by-passing some portion of oil from the delivery branch pipe into the suction one along duct D.

Spring 39 presses the by-pass valve to the seat in the housing. Adjustment of spring tension is carried out with the aid of adjusting screw 37 driven into valve housing cap 35 and locked by cup nut 36.

The pump bearings are lubricated with oil which flows through the end face clearances between the gears and the sealing partitions and then runs into the suction cavities of both sections via holes available in cover 29, housing 18, sealing partitions 19 and housings of sections 1 and 34.

From the bearings located in scavenging section cover 13 the oil flows into the housing of the major accessories drive.

The pumps installed on diesel engines of clockwise and counter-clockwise rotation are not interchangeable and differ in the design of the housings and direction of rotation.

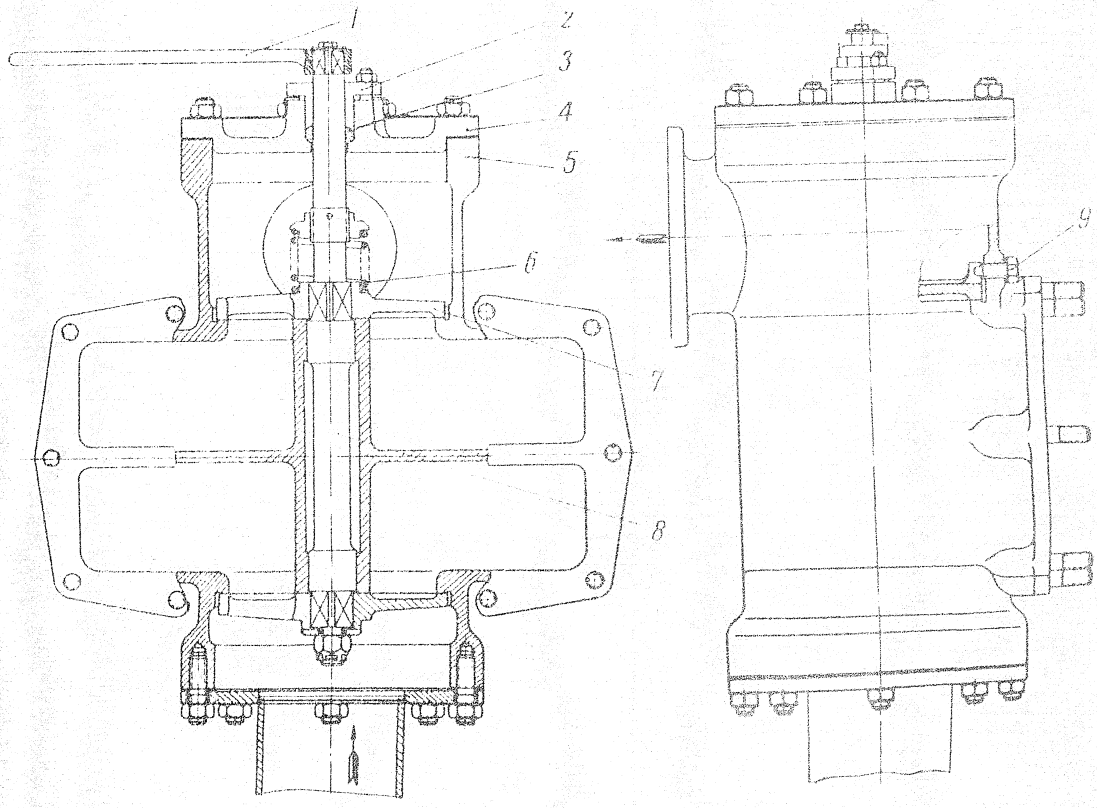

FIG. 33. OIL FILTER GATE

1 – handle; 2 – pressure bushing; 3 – oil seal; 4 – cover; 5 – gate body; 6 – spring; 7 – valve; 8 – shaft; 9 – bolt

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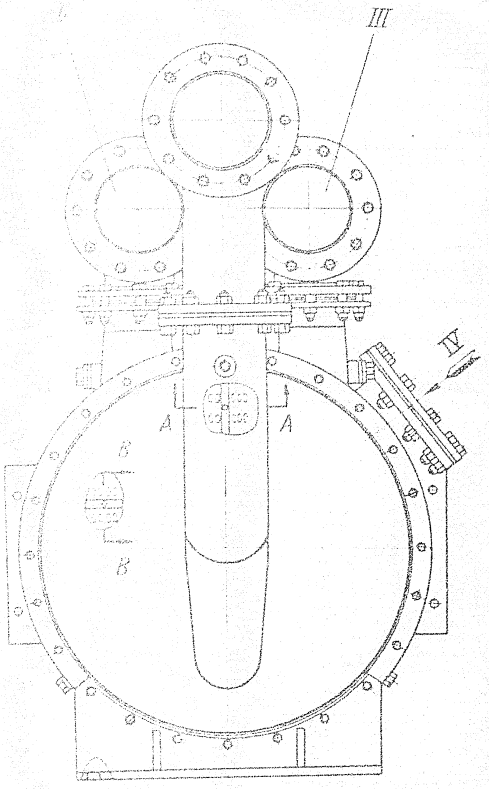

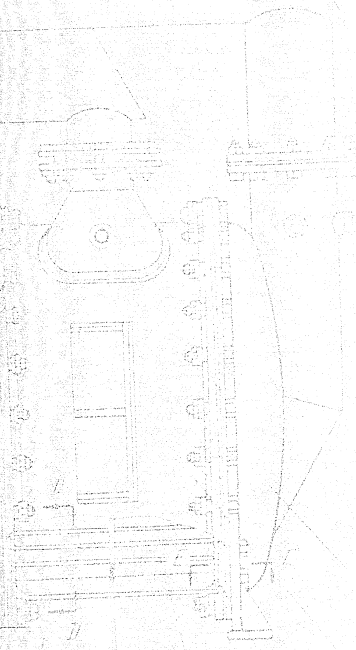

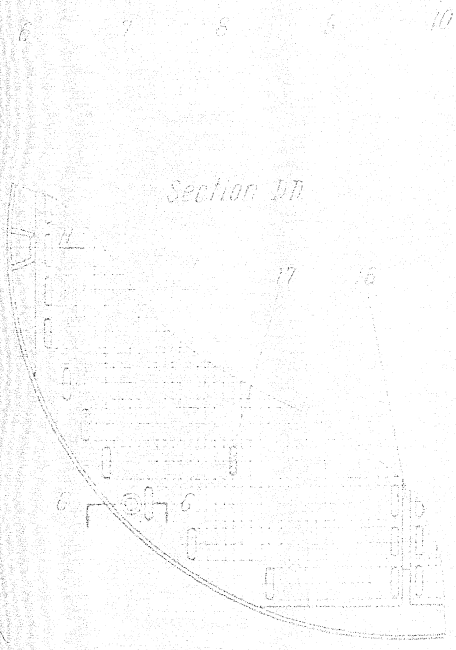

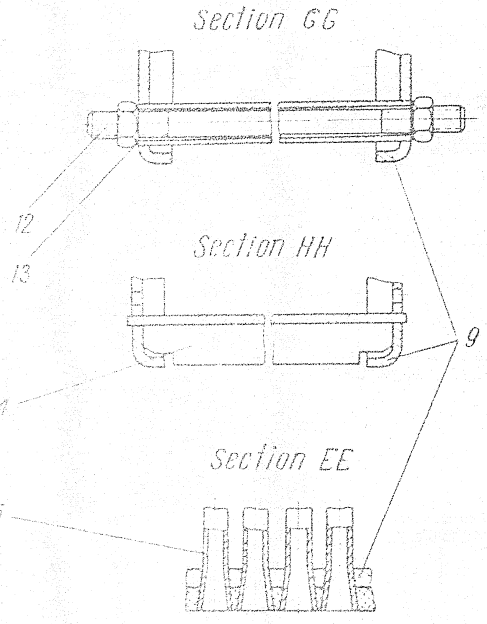

... 5 – trackway; 6 – cooler housing; ... bushing; 12 – stiffening tube; 13 – spanner bar spacer; 15 – cooling element pipe; 16 – partition; ... 17 – support strip; I – oil outlet; II – water inlet (outlet); III – water outlet (inlet); IV – oil inlet.

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OIL FILTER

Two filters of similar design are provided in the suction and delivery lines of the system, to clean the oil.

The filter is one of the screen-double-section type. Each section accommodates three filtering cartridges 6 (Fig.32). Stops 7 and gate 14 connect both sections into a common unit.

The filtering cartridge comprises steel pipe 5 which is provided with oil slots and carries filtering sections 12 and aluminium diaphragms 11 clamped by nut 9 between upper disc 4 and lower disc 8. The double-layer filtering sections (fine screen with 0.14 x 0.14 mm mesh, and a supporting coarse-mesh screen) are edged along the outer and inner diameters by aluminium collars. Sealing of upper disc 4 in the bore made in the horizontal partition of casing 2 is ensured by its respective fit. Pipe 3 welded to casing cover 1 prevents axial travel of cartridge 6.

To discharge the residue, the casing lower part is provided with drain plug 16 and pipe union 13. Cock 15 serves for taking oil samples.

The gate (Fig.33) is an aluminium alloy casting. Two valves 7 fitted on shaft 6 have sector-shaped cuts for oil to pass. Spring 6 presses the valves constantly to their seats. The place where shaft 8 comes out of cover 4 is sealed by means of oil seal 3 provided with pressure bushing 2.

Gate handle 1 may be set in one of the following three positions:

(1) central position, to engage both sections;

(2) when the handle is moved 90° to the right or left from central position, the valves shut off the inlet and outlet of oil for one of the sections, and leave them open for the other section.

The turn of the handle is limited by bolt 9 and by the stop on the valve disc. Gate upper cover 4 carries a special table which bears the respective inscriptions.

OIL COOLER

To cool the oil, the system is provided with an oil-to-water cooler consisting of two cooling sections 3 and 10 (Fig.34), distance piece 4 located between the sections, two covers 1 and 11, oil and cooling water supply and return pipes, and four brackets 5 which hold the cooler to the foundation. The cooler is installed in horizontal position.

Each cooling section comprises brass welded housing 6 with cooling element 8 soldered into it. The cooling element consists of flat pipes 15, two tube plates 9, partition 16, four turnbuckles 12 with spacing tubes 13, six flat anchor stays 17, diaphragm 7, and two channel-bar spacers 14. Oil is fed into distance piece 4, whence it flows simultaneously into both sections 3 and 10, passes along pipes 15 of cooling elements 8, and gets into the covers. From the covers the oil is directed into a common pipe, and further into the system.

Water of the outer circuit is supplied to the inlet branch pipe of each section, runs into the section, by passes partition 16 and flows into the water outlet pipe.

Zinc protectors 2 are mounted on the inlet branch pipes of the cooling sections to prevent corrosion.

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Chapter IX

COOLING SYSTEM

The diesel engine is cooled with fresh water circulating along a closed circuit. Fresh water, oil and scavenging air are cooled with sea water. Therefore, the diesel engine cooling system is divided into fresh water system and sea water system.

FRESH WATER SYSTEM

Diesel engine fresh water pump 7 (Fig.35) delivers water to pneumatic regulating slide valve 2 of the thermoregulator, and forces it further through fresh water cooler 1 or along the by-pass pipe past the cooler into two water manifolds 6 located on both sides of the diesel engine and also into the turbo-supercharger cooling line.

The amount of fresh water passing through cooler 1 and through the by-pass pipe past the cooler is determined by the position of slide valve 2; this position is set by thermoregulator control unit 16, depending on the temperature of water flowing out of the engine.

From water manifolds 6, water is directed to cool all the sections of exhaust manifolds 5 along the connecting branch pipes. From the cooling cavities of each exhaust manifold section the water overflows into cylinder sleeve cooling cavity 8 in two ways:

(a) through port D (see Fig.19) made in the section inner wall, and through passages drilled in the lands between the working cylinder sleeve exhaust ports;

(b) through the gap between the section cover and cylinder sleeve.

The water circulating in the water jacket cools the sleeve walls and the pipe unions of the injectors and starting valves.

From the working cylinders the water is returned through holes available in the upper part of the sleeve jackets and through branch pipes 4 (Fig.35) into return pipes 3 located along the diesel engine, and further it is directed to the suction line of pump 7.

Initial priming of fresh water into the system is done through expansion tank 13. The tank communicates through a pipe with the suction line of pump 7, and thus ensures reliable functioning of the closed system when the water volume changes due to heating.

The diesel engine water inlet and outlet temperature is checked by means of thermometers 10 and 14, while the engine water inlet pressure is checked by means of pressure gauges 11.

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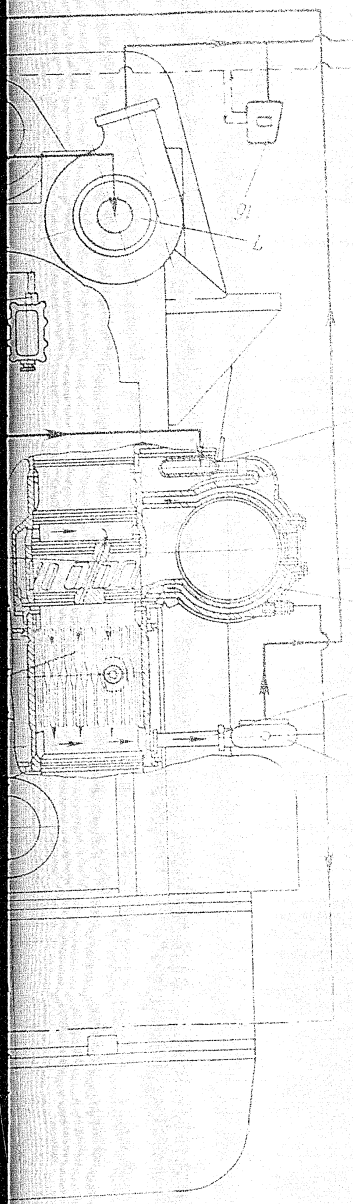

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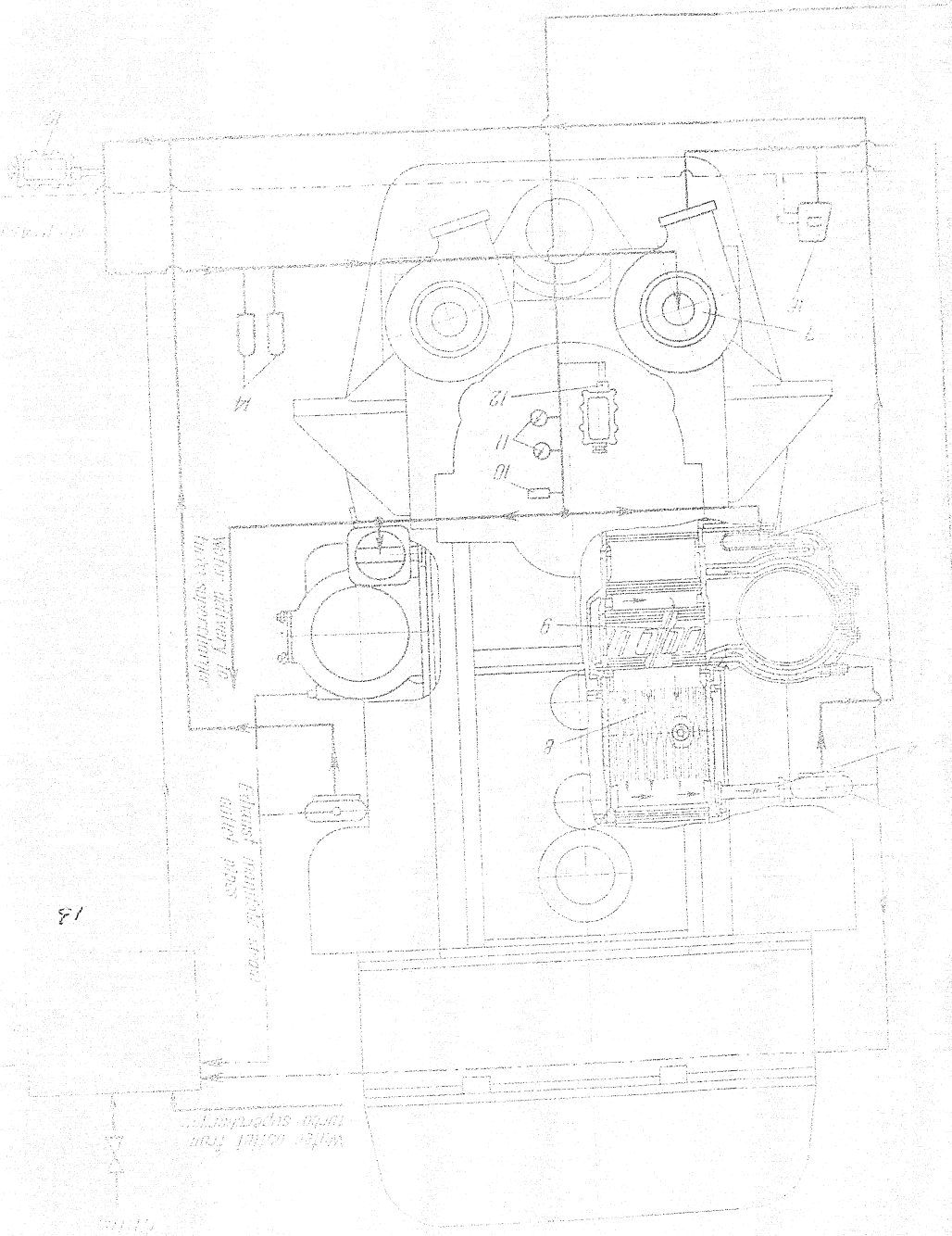

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The temperature and pressure of water in the system are checked by the automatic warning signalling system.

The signalling sensors 2, 4 and 14 (Fig.30) are mounted on the inlet and outlet pipes with temperature sensor 15 and combination relay with pressure sensor 13, respectively, mounted on the respective pipelines.

The air penetrating into the system and the vapour generated in it, are bled into expansion tank 13 through the bleeding pipes running from the cylinder manifolds 9 and through return pipes 3.

The water used for cooling the cylinder superchargers is also returned into tank 13.

To warm up the engine before starting, the ship's system should be provided with hot water inlet and outlet and a non-return valve.

SEA WATER SYSTEM

Diesel engine sea water pump 2 (Fig.30) sucks in the water from the kingston valve through filter 4 and forces it via thermoregulator regulating slide valve 5 successively into oil cooler 7 and water cooler 8, while part of water is fed into scavenging air coolers 1.

The amount of water passing through the air coolers is regulated by means of valves mounted in the supply and return pipes.

The pipelines supplying and returning water to/from oil cooler 7 communicate with each other through a by-pass pipe and thermoregulator regulating slide valve 5. The amount of cooling water which passes through oil cooler 7 and through the by-pass pipe is determined by the position of slide valve 5; this position is set by thermoregulator control unit 6, depending on the temperature of oil flowing out of cooler 7.

The pressure of water at the inlet of thermoregulator slide valve 5 is checked by means of pressure gauge 3.

WATER PUMP

Circulation of fresh and sea water in the diesel engine cooling system is ensured by two centrifugal pumps of a similar design. The pumps are installed on the engine bow end face (on the housing of the major accessories drive).

Pump impeller 1 (Fig.37) is fitted on the taper part of shaft 16 and is secured on it by key 2 and nut 3. Nut (fairing) 3 is locked on shaft 16 by plate washer 4.

The shaft is supported on one radial ball bearing 18 and two radial-thrust ball bearings 17. Axial travel of shaft 16 with impeller 1 is limited by radial-thrust ball bearings 17, whose outer races face each other (by the narrow end faces) and are loose-fitted into cage 15.

The bearings are lubricated with oil splashed through the housing passages.

Leakage of water along the shaft is prevented by a seal arranged in the depression made in the hub of impeller 1. The seal includes oil seal bushing 11 with graphite ring 10 glued into it, steel ring 9 running over the graphite ring, rubber ring 7, spacer ring 8, and spring 6.

Sealing of the oil cavity is ensured by a labyrinth seal formed by oil slinger 13 and cover 12. The leaking water and oil flow down along passage A available in the pump housing.

Air is discharged from the pump through the cock fitted on the volute. All parts of the fresh and sea water pumps employed in one engine are similar in design and, therefore, they are interchangeable.

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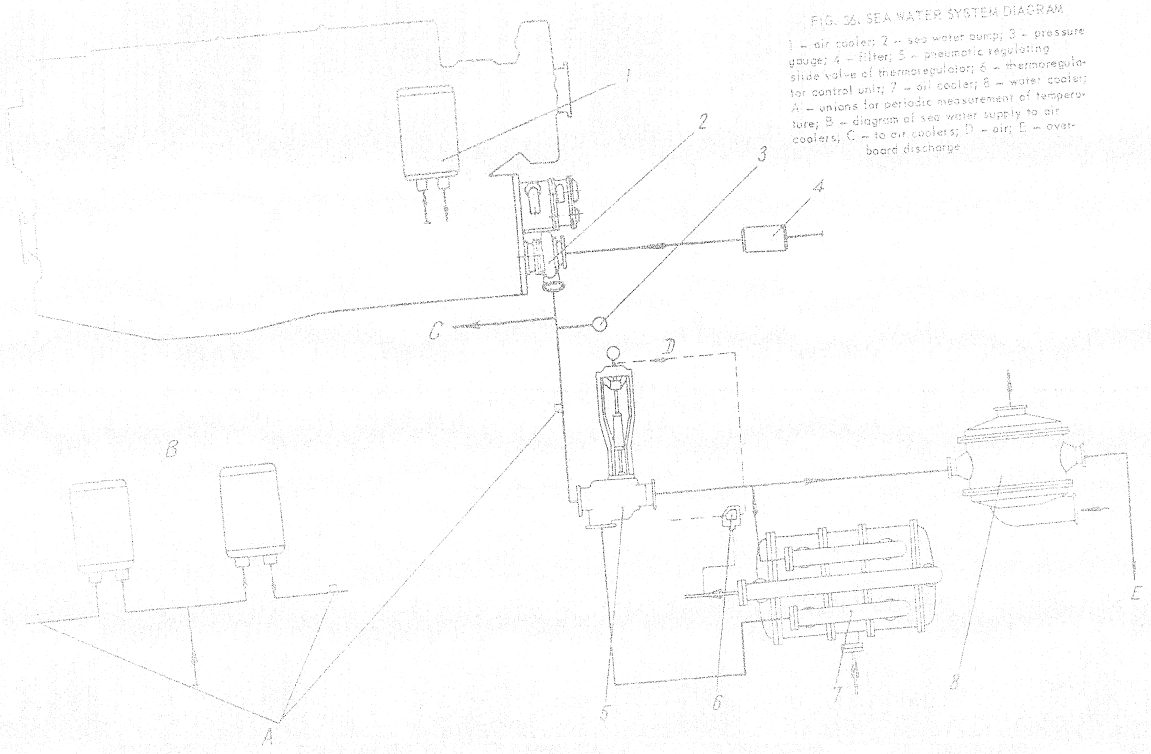

FIG. 36. SEA WATER SYSTEM DIAGRAM

1 – air cooler; 2 – sea water pump; 3 – pressure gauge; 4 – filter; 5 – pneumatic regulating slide valve of thermoregulator; 6 – thermoregulator control unit; 7 – oil cooler; 8 – water cooler; A – unions for periodic measurement of temperature; B – diagram of sea water supply to air coolers; C – to air coolers; D – air; E – overboard discharge

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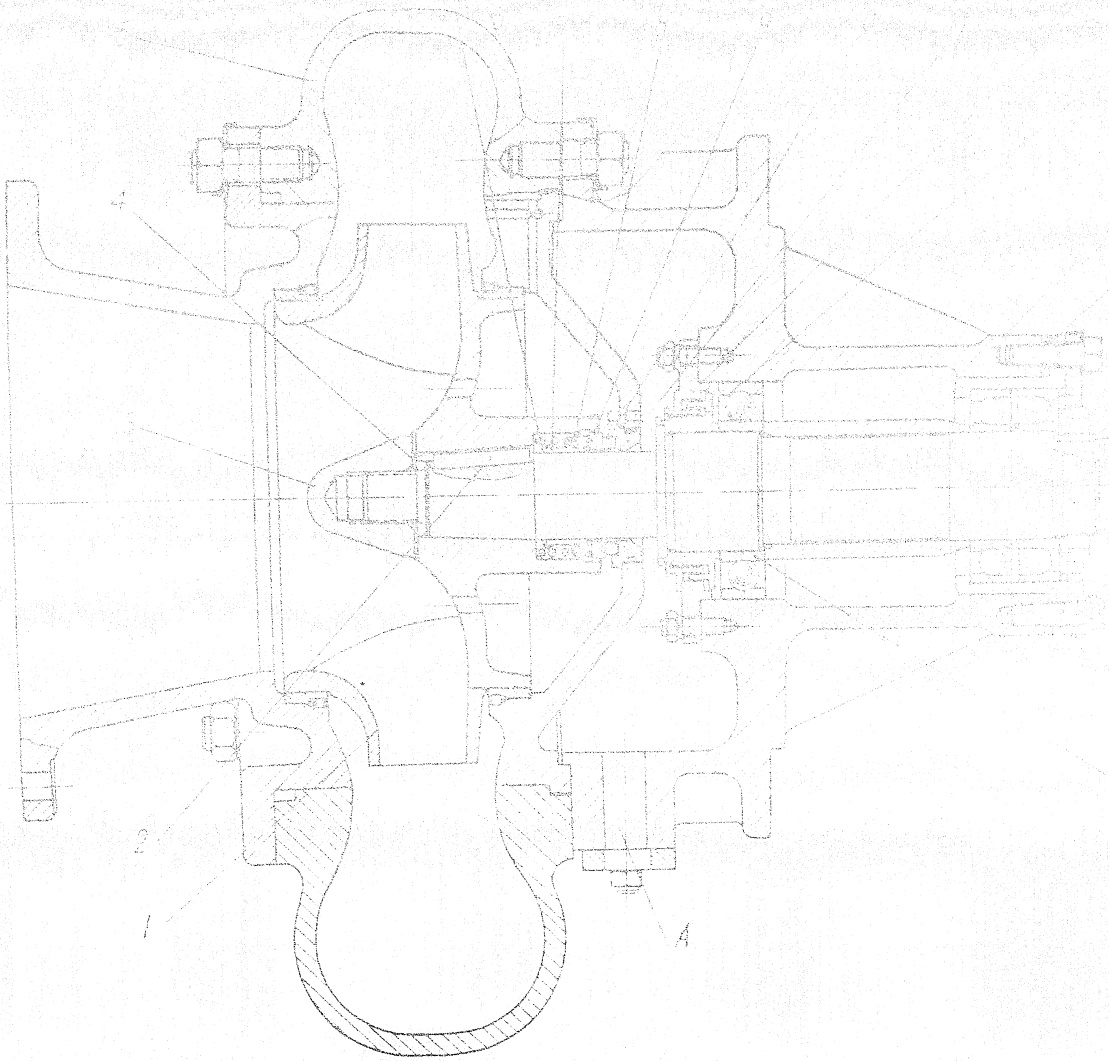

FIG. 37. FRESH (SEA) WATER PUMP

1 – pump impeller; 2 – key; 3 – nut (fairing); 4 – plate washer; 5 – volute; 6 – spring; 7 – rubber ring; 8 – spacing ring; 9 – ring; 10 – graphite ring; 11 – oil seal bushing; 12 – cover; 13 – oil slinger; 14 – housing; 15 – cage; 16 – shaft; 17 – radial-thrust bearing; 18 – radial bearing

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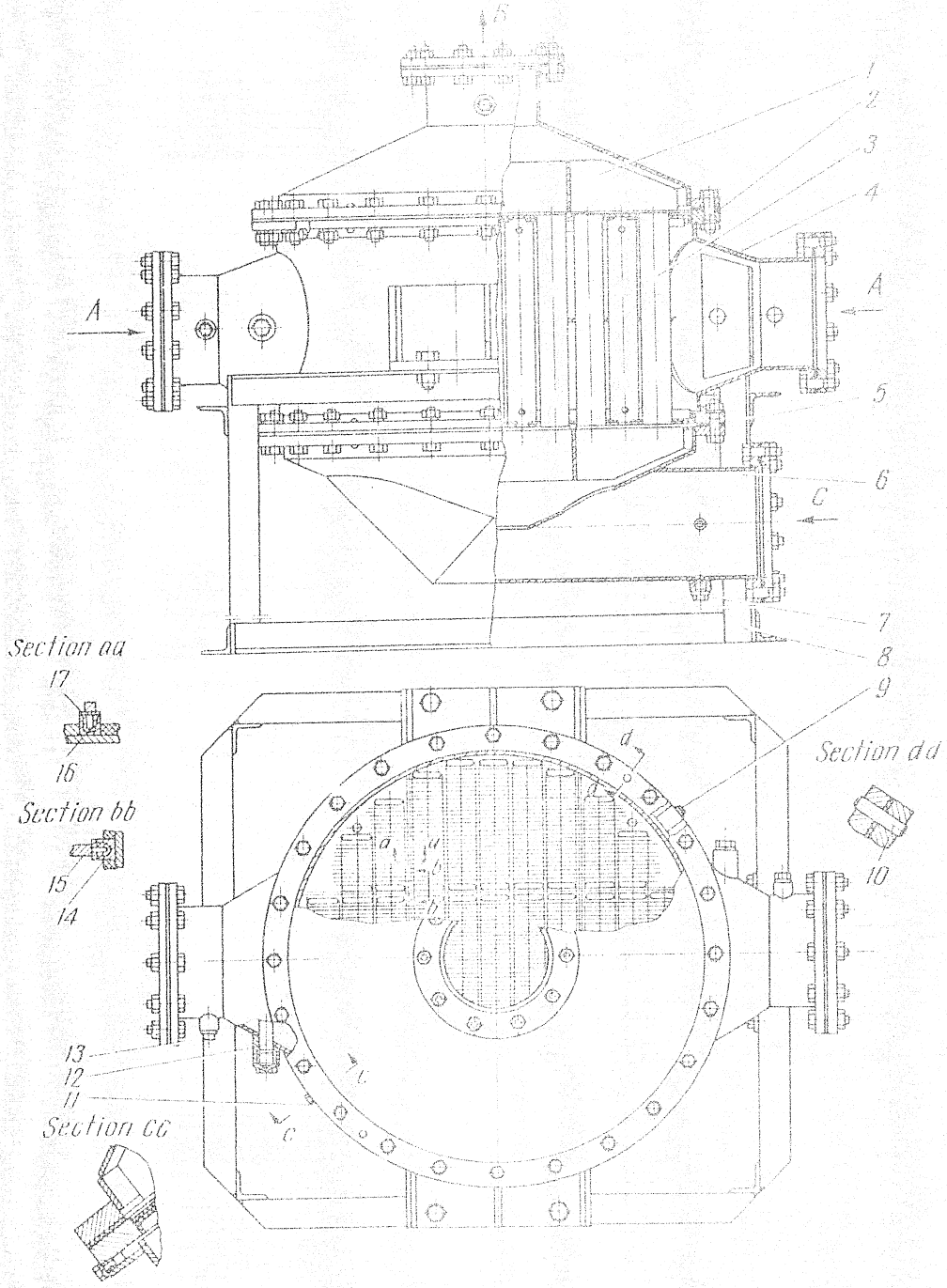

FIG. 28. FEEDWATER COOLER

1 – upper cover, 2 – gasket, 3 – heat-exchanger unit, 4 – housing, 5 – gasket, 6 – lower cover, 7 – plug, 8 – fixture, 9 – plug, 10 – pin, 11 – plug, 12 – protector, 13 – plug, 14 – stud, 15 – [illegible] 16 – stud, 17 – gasket, a – water inlet or outlet, b – branch outlet pipe, c – [illegible]

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FRESH WATER COOLER

The fresh water cooler comprises housing 4 (Fig. 38), heat-exchanging unit 3, and two covers (upper cover 1 and lower cover 6).

Cooler welded housing 4 is made of brass. Welded to the housing shell are two steel brackets for fastening the cooler to the foundation, and two branch pipes with flanges for supplying and returning sea water.

Steel welded covers 1 and 6 are provided with inner ribs which serve as a support for the tube plates.

Heat-exchanging unit 3 is mounted in the bores made in the flanges of housing 4 and is soldered there. The heat-exchanging unit consists of a frame and 775 flat cupronickel pipes provided with holes.

The frame of the heat-exchanging unit is formed by the tube plates and the diaphragm interconnected by means of four coupling studs, two channel-bar crossplecce and eighteen brass bars, which serve as struts between the tube plates.

The tube plates and diaphragms are made of sheet copper.

After the pipes are fitted into the frame, the pipe ends should be beaded, and a layer of solder should be deposited on the tube plate surfaces, so as to solder stops 14 and 16 by means of which the tube plates rest against the cover ribs through paronite gaskets 15 and 17. The paronite gaskets are pinned to the stops. The joints between the housing and the covers are sealed by paronite gaskets 2 and 5. The position of the covers during assembly is secured by means of taper pins 10.

Fresh water circulating in the diesel engine gets into the cooler through the branch pipe of lower cover 6, passes along the cooler pipes washed over with sea water, and flows out through the branch pipe of upper cover 1. Sea water is supplied and returned through the cooler housing branch pipes provided with rod-type zinc protectors 12 preventing the cooler parts from being attacked by sea water.

Threaded holes closed with plugs 7 and 13 are made in the housing and covers, to mount the measuring instruments.

Air is discharged from the sea water cavity through a hole closed with plug 9, while water is drained out through a hole closed with plug 11.

The cooler is secured on frame 8 to ensure convenience of its transportation.

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Chapter X

STARTING AND SPEED-CONTROL SYSTEM

The remote control pneumatic system consists of a panel mounted beyond the diesel engine, mechanisms and arrangements installed on the engine, and pipelines which connect all the elements of the system.

The control system ensures starting the engine, a change of its speed, and stopping the engine.

The engine is provided with an emergency control station and a selector switch which makes it possible to change over the control from the panel to the emergency control station, and vice versa.

The diesel engine control diagram is shown in Fig.39.

AIR FILTER

The air filter (Fig.39a) mounted in the control air system ensures better cleaning of air.

The filter consists of body 1 closed on top by flange 6, pipe 2 with a screen, and a stack of bakelite-treated paper plates 3 pressed up by spring 4.

The moisture is drained out through cock 5. Mechanical particles are trapped by the stack of paper filtering plates 3.

REMOTE CONTROL PANEL

The design of the diesel engine control panel is shown in Fig.40a.

The welded frame of panel body 1 is closed on all sides with steel plates. The panel front and side walls are provided with holes for inspecting and lubricating the mechanisms. The holes are closed with covers.

The panel face wall carries the following measuring instruments: electric tachometer indicator 7, oil pressure gauge 10, fresh and sea water pressure gauges 11 and 4, starting air pressure gauge 8, and multivoltmeters 6 to measure the temperature of gases in the diesel engine gas exhaust manifolds. The instruments are closed on top by aluminium cover 9.

Housed inside the body are: panel control mechanism and intermediate starting valve 3, attachment necks 17 and 18 for attaching the pipelines, and cock 16 whose spindle extends to the panel side wall.

Hand control wheel 15 is mounted on plate 2 (Fig.40b) secured on two angle brackets of the

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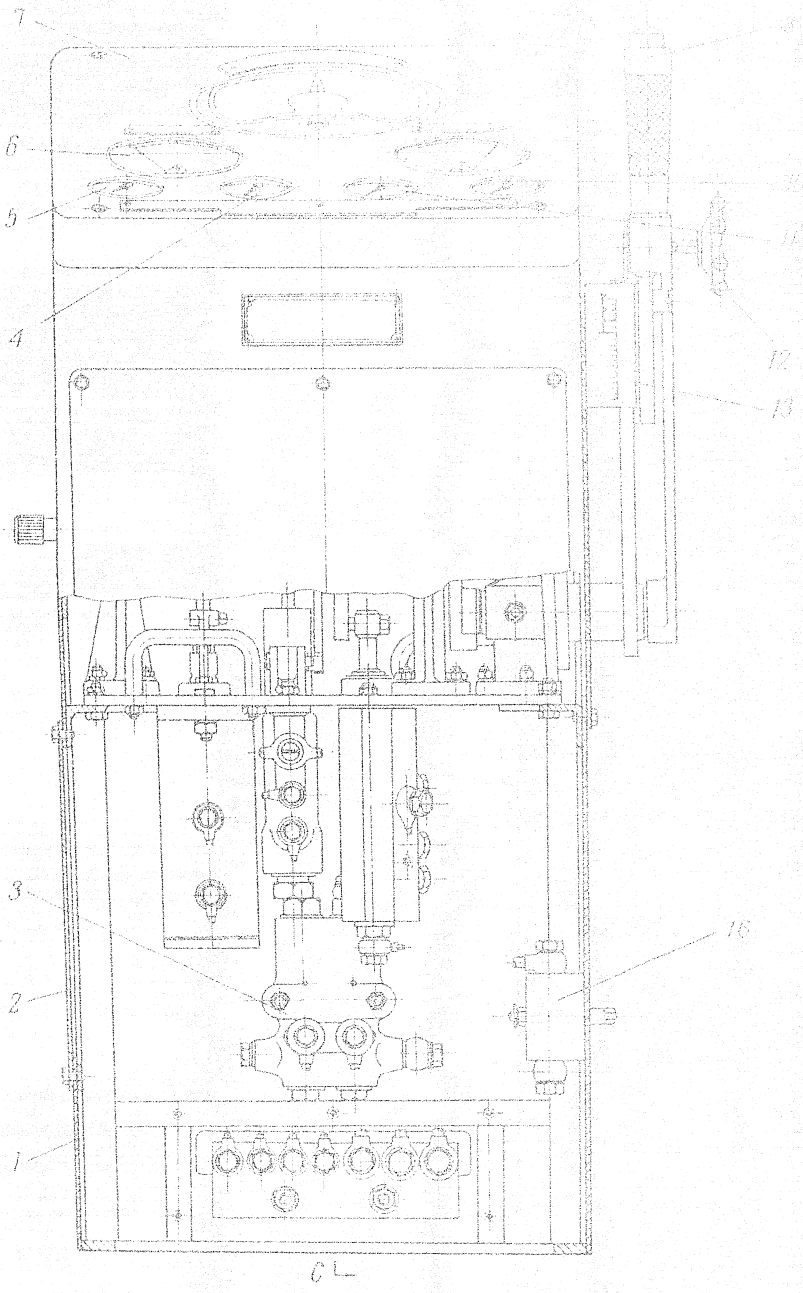

FIG. 40a. DIESEL ENGINE

1 – panel body; 2 – side cover; 3 – intermediate starting valves; 4 – SEA WATER pressure gauge; 5 – AIR pressure gauge; 6 – millivoltmeter; 7 – electric tachometer indicator; 8 – control handle; 9 – panel cover; 10 – OIL pressure gauge; 11 – FRESH

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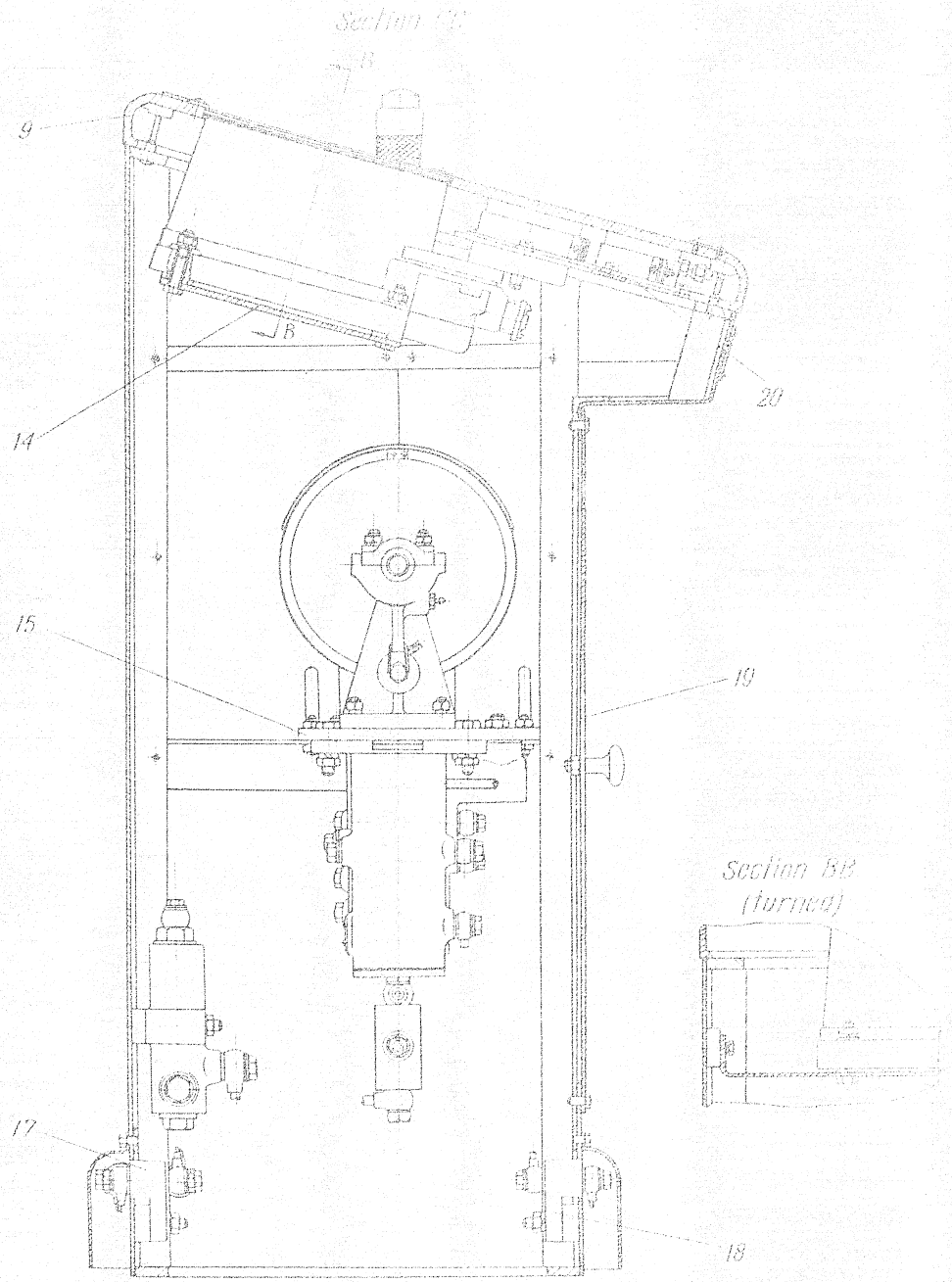

REMOTE CONTROL PANEL

WATER pressure gauge; 12 – speed rise adjustment knob; 13 – indicating scale; 14 – tachometer mounting plate; 15 – control mechanism; 16 – cock; 17, 18 – attachment blocks; 19 – front cover; 20 – pressure gauge plate

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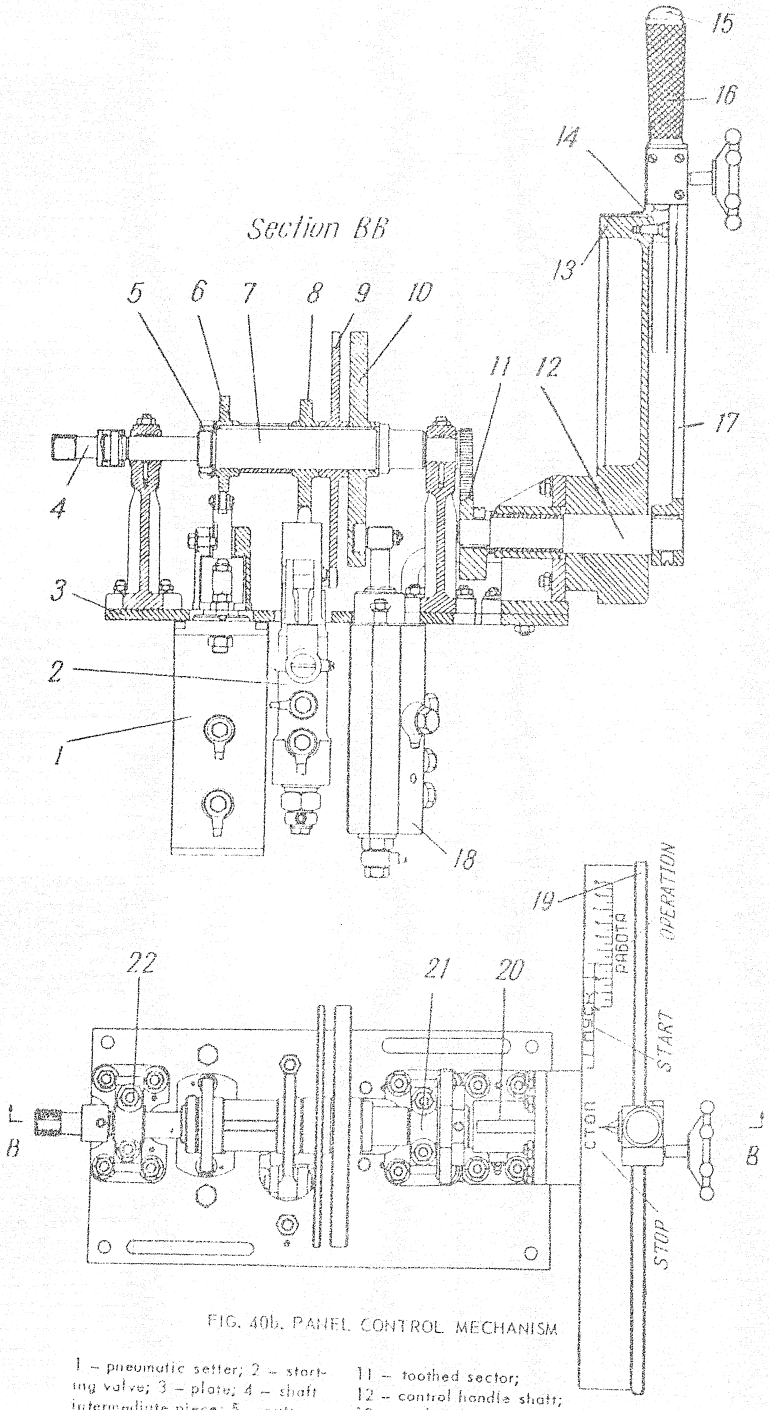

FIG. 40b. PANEL CONTROL MECHANISM

1 – pneumatic setter; 2 – starting valve; 3 – plate; 4 – shaft intermediate piece; 5 – nut; 6 – speed restricting plate; 7 – shaft; 8 – starting valve plate; 9 – latch release plate; 10 – plate of intermediate starting valves slide valve; 11 – toothed sector; 12 – control handle shaft; 13 – scale; 14 – indicator; 15 – control handle rod; 16 – control handle; 17 – handle base; 18 – slide valve of intermediate starting valves; 19 – sector; 20, 21, 22 – bearings

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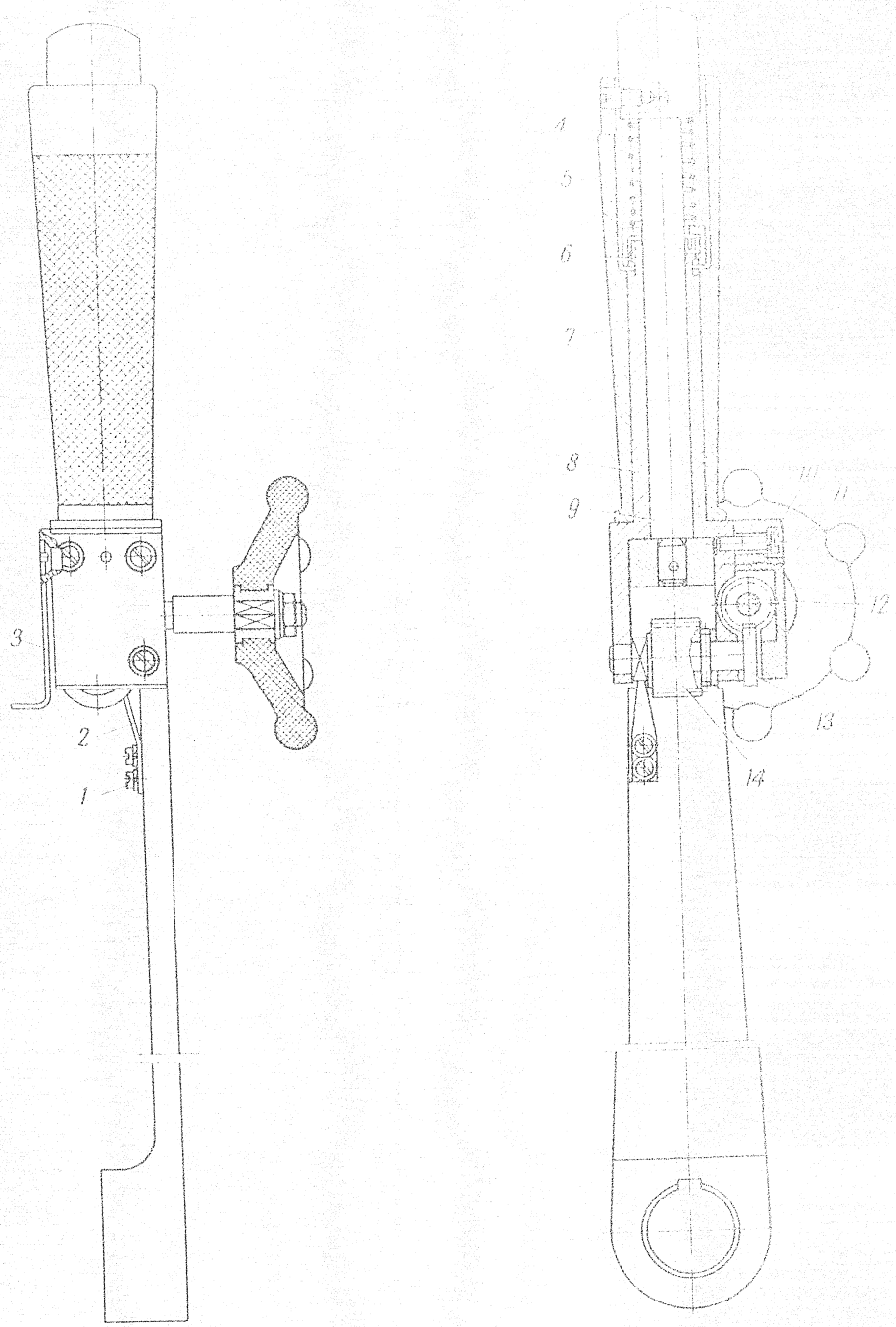

FIG. 40c. CONTROL HANDLE WITH SPEED FINE ADJUSTMENT MECHANISM

1 – knob; 2 – spring; 3 – indicating pointer; 4 – locking screw; 5 – spring; 6 – nut; 7 – handle; 8 – guide; 9 – rod; 10 – screw; 11 – cover; 12 – worm; 13 – helical gear; 14 – worm

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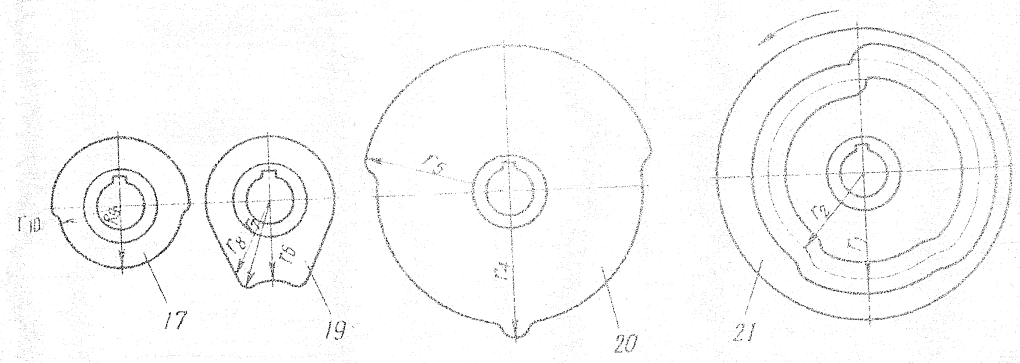

FIG. 40d. CONTROL CAM PLATES

17 – speed restricting plate; 19 – starting valve plate; 20 – latch release plate; 21 – plate of intermediate starting valves slide valve

Position of indicating pointer	Radius of cam plate profile at roller or tappet	Result of cam operation	Position of indicating pointer	Radius of cam plate profile at roller or tappet	Result of cam operation	Position of indicating pointer	Radius of cam plate profile at roller or tapper	Result of cam operation
Cam plate 21 of intermediate starting slide valve			Latch release cam plate 20			Speed restricting cam plate 17		
STOP zone	r_1	Slide valve is in central position in which it closes the pipes operating the intermediate starting valves. The above valves are herein closed. Air is admitted to servo-motor unit	STOP	r_4	Starting valve lever is shifted down, latch released and valve closed	STOP	r_9	Governor control shaft is in position STOP
			Extreme notch of START zone	r_5	Starting valve lever is shifted down, valve latch released, valve closed	Division "0" in OPERATION zone	r_{10}	Governor control shaft starts shifting from position STOP to increase of speed
START zone	r_2	Slide valve admits air from starting valve to intermediate starting valve	Starting valve cam plate 19					
			STOP zone	r_6	Starting valve closed			
			Between STOP zone and first division of START zone	r_7	Starting valve opens when the handle is turned from STOP to START			
			Between first division of START zone and STOP zone	r_8	Starting valve opens when the handle is turned from START to STOP			

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Shaft 7 runs in bearings 21 and 22, and carries the following parts: cam plate keyed to it, restricting cam plate 6, starting valve cam plate 5, cam plate fixed on the slide valve of intermediate starting valve. Nut 5 keeps the plates against axial travel. Starting valve 2, slide valve of intermediate starting valve, and setter 1, which are controlled by the above cam plates, are fixed to the bottom part of mounting plate 3.

One end of the shaft carries splined intermediate piece 4 pinned to the shaft. The latter piece is used for turning control shaft 7 from duplicating panels or arrangements which control the entire installation.

Bearing 21 is a thrust one and prevents axial travel of the shaft.

The extreme positions of the shaft with cam plates are limited by a stop.

Control handle shaft 12 runs in bearing 20. Keyed to the shaft is toothed sector 18 engaging the gear of shaft 7. The control handle is connected rigidly to shaft 12. Worm toothed sector 19 is mounted on a sector attached to bearing 20.

Starting and control of diesel engine are done by means of one handle 8 (Fig.40b). The pointer available on the handle shows the position of the handle on scale 13.

Fine adjustment of speed is carried out with the aid of knob 1 (Fig.40c). During [illegible] knob, worm 14 runs along sector 19 (Fig.40b), moves handle 16 and sets the required [illegible]. The knob serves also for securing the handle in a definite position.

According to their functions, all the devices of the panel pertain either to the starting system or to the speed control one.

The panel starting system (Fig.39) comprises starting valve 23 (see also Fig.42), starting valve cam plate 19, starting valve latch release plate 20 (see also Fig.40d), slide valve 25 of intermediate starting valves (see also Fig.43), and intermediate starting valves 26 (see also Fig.44).

The starting valve (Fig.42) admits air and shuts off the air supply to the slide valve of intermediate starting valves.

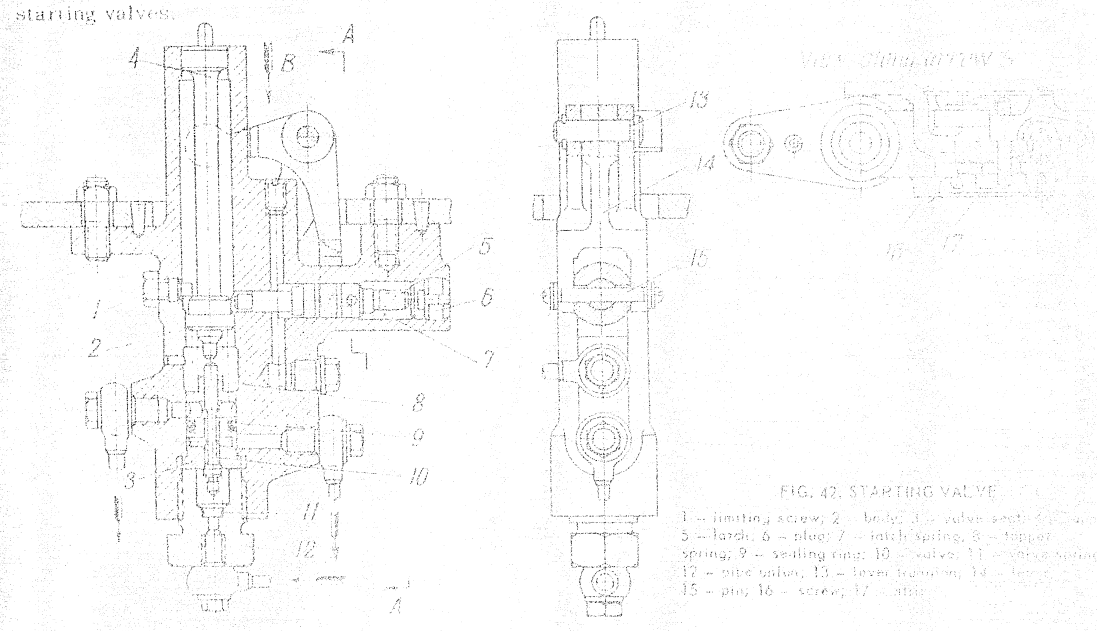

FIG. 42. STARTING VALVE

1 – limiting screw; 2 – body; 3 – valve seat; 4 – [illegible]; 5 – latch; 6 – plug; 7 – latch spring; 8 – tripper spring; 9 – sealing ring; 10 – valve; 11 – valve spring; 12 – pipe valve; 13 – lever fulcrum; 14 – lever; 15 – pin; 16 – screw; 17 – [illegible]

The slide valve of intermediate starting valves (Fig.43) feeds air from the starting valve to the intermediate valves.

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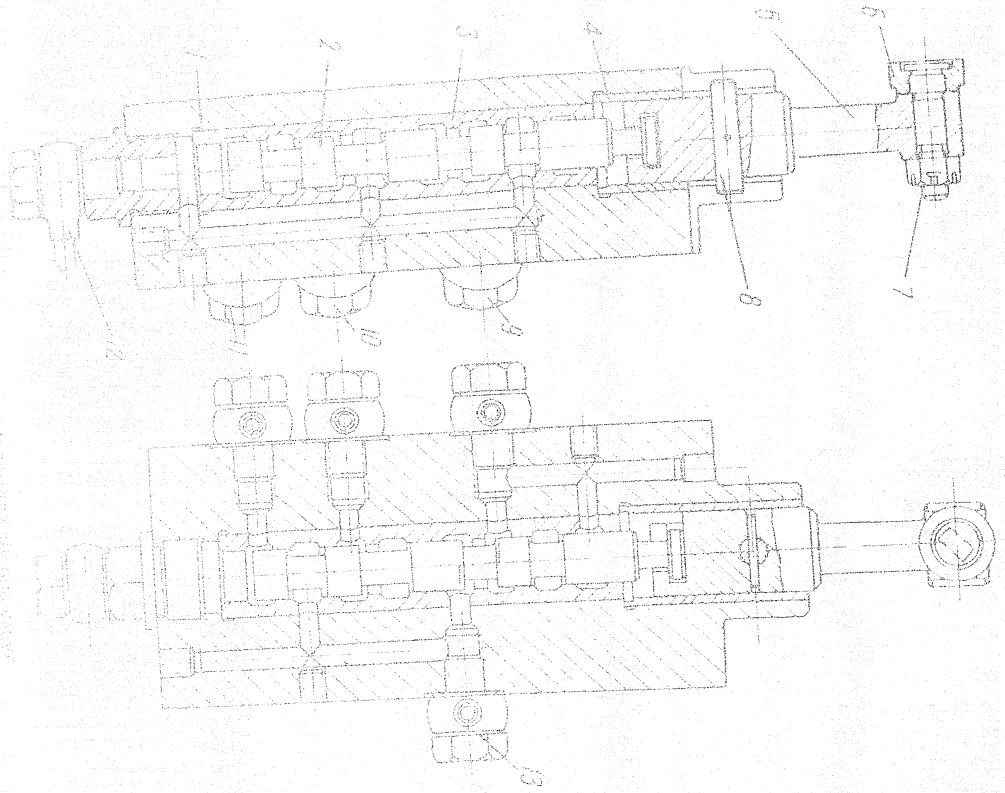

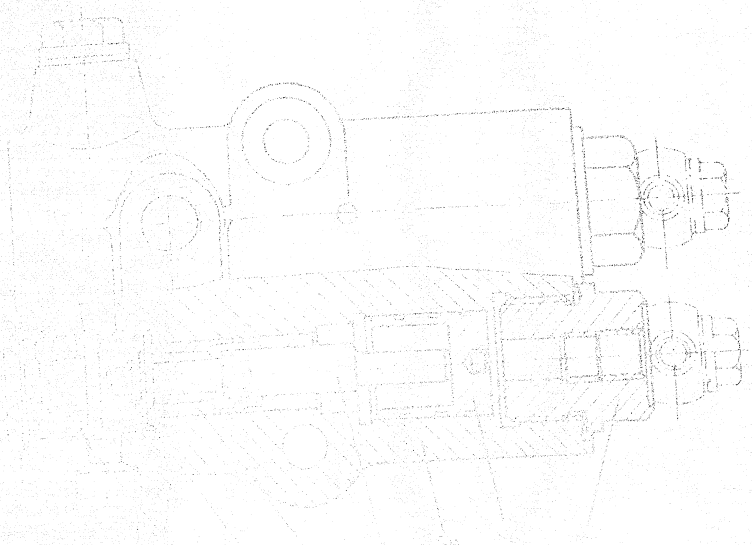

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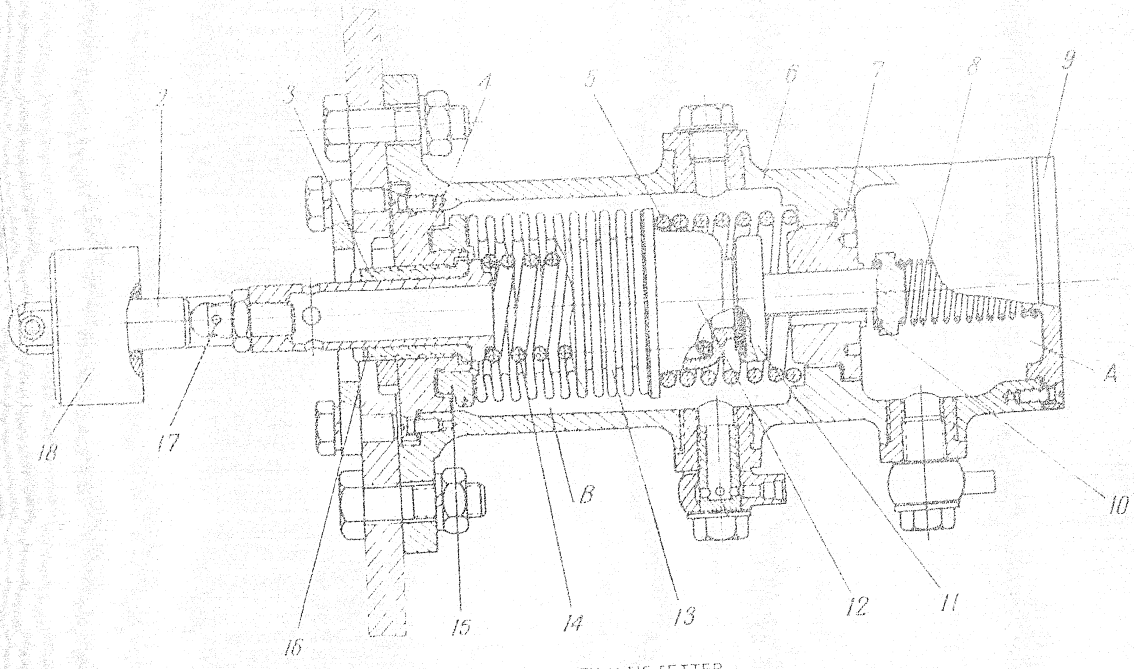

FIG. 45. PNEUMATIC SETTER

1 – ball bearing; 2 – shaft; 3 – adjusting nut; 4 – upper cover; 5 – balancing spring; 6 – body; 7 – seat; 8 – spring; 9 – lower cover; 10 – guide; 11 – disc; 12 – jet; 13 – bellows; 14 – spring; 15 – ring; 16 – rod; 17 – tappet; 18 – stand

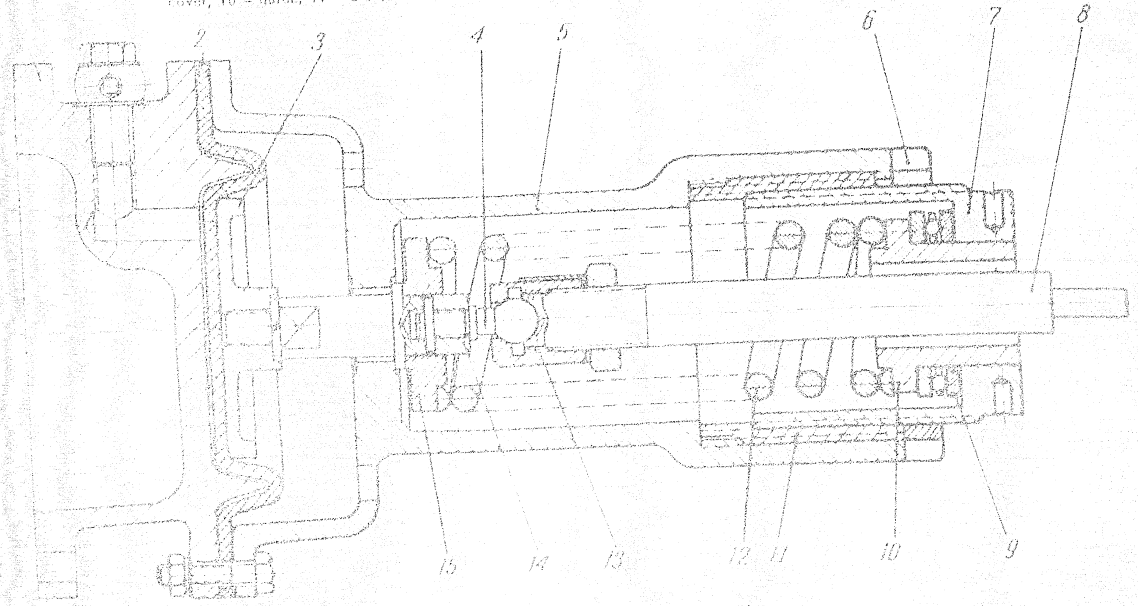

FIG. 46. SPEED-CONTROL SERVOMOTOR

1 – cover; 2 – membrane; 3 – disc; 4 – ball ring; 5 – housing; 6 – seat; 7 – adjusting nut; 8 – rod; 9 – bearing; 10 – plate; 11 – diaphragm; 12 – sector; 13 – hinge nut; 14 – tappet; 15 – disc

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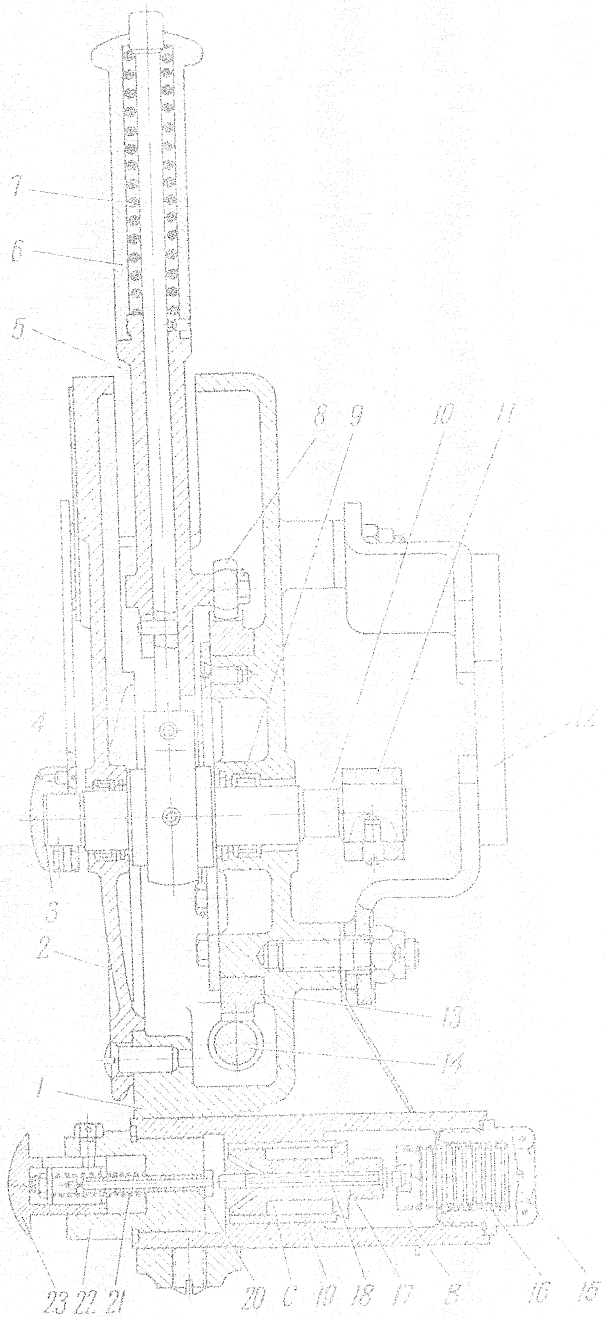

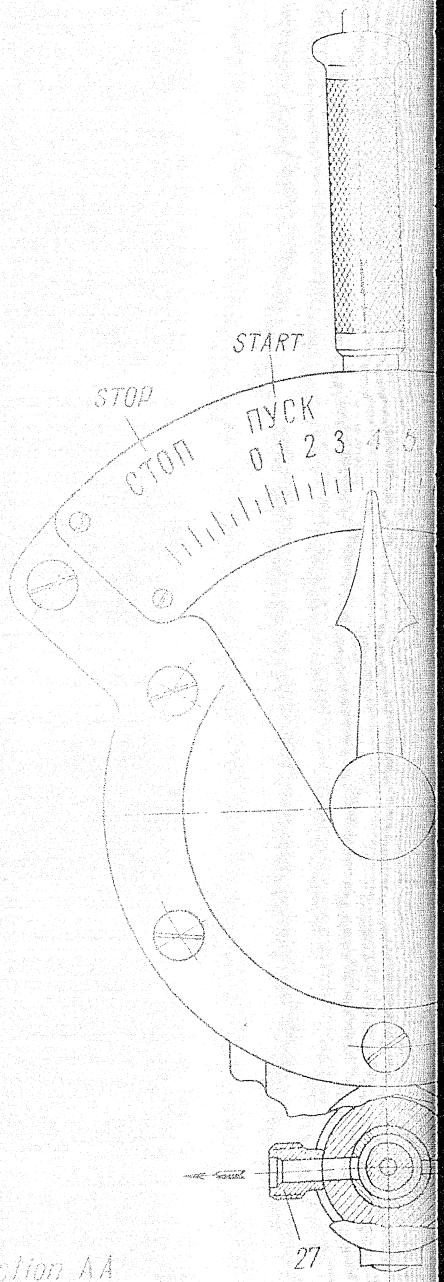

Section AA

FIG. 47. EMERGENCY CONTROL STATION

1 – control station housing; 2 – cover; 3 – sleeve; 4 – pointer; 5 – lever; 6 – handle; 7 – spring; 8 – lock; 9 – needle bearing; 10 – shaft; 11 – lever; 12 – bracket; 13 – gear; 14 – worm; 15 – plug; 16 – spring; 17 – valve; 18 – control valve; 19 – starting valve body; 20 – relief valve; 21 – spring; 25 – knob; 26 – air supply pipe union; 27 – air

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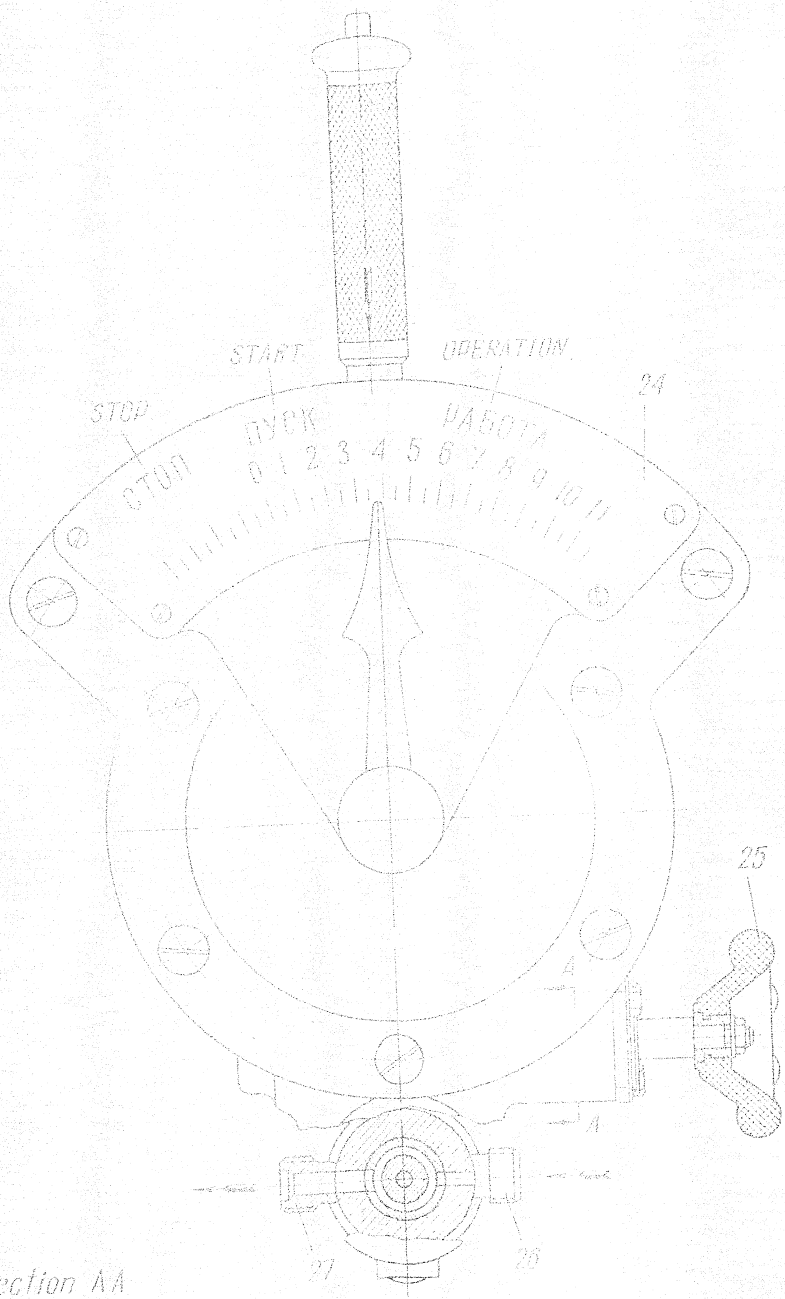

FIG. 47. EMERGENCY CONTROL STATION

...ter; 5 – lever; 6 – handle;
... lever; 12 – bracket;
18 – control valve; 19 – start-
...ing valve body; 20 – relief valve; 21 – spring; 22 – plunger; 23 – button; 24 – scale;
25 – knob; 26 – air supply pipe union; 27 – air inlet pipe union

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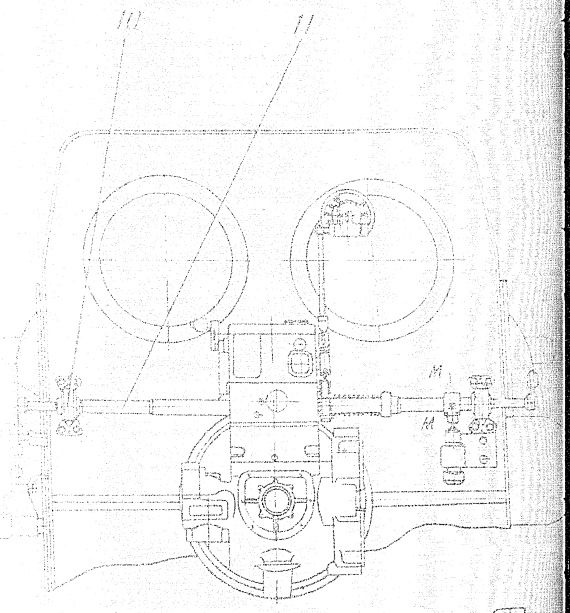

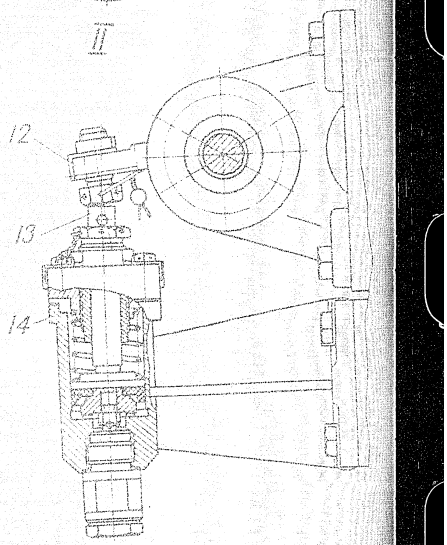

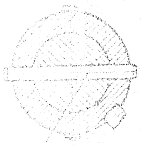

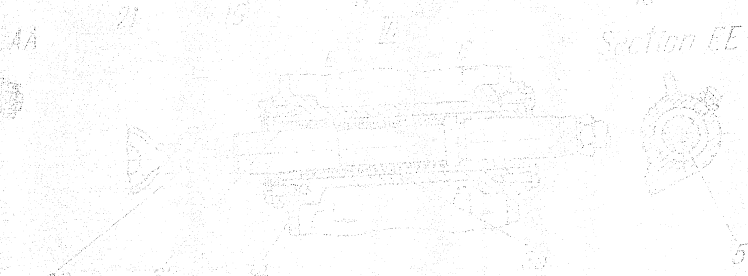

CONTROL SHAFTS, RODS AND [illegible]

26 – spring; [illegible] 29 – mounting; 30 – rod; 31 – stud; 31 – pin; 32 – lock-
pin; 33 – spring; 34 – beam; 35 – support; 36 – lever; 37 – sleeve; 38 – housing; 39 – rod; 40 – emergency
control shaft; [illegible] 42 – [illegible] governor regulating mechanism

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Centrally Set [illegible]

The setter serves for [illegible] the air [illegible] in the cavity of the servo motor (Fig.46), depending on the form of the control panel handle.

Setter body 6 (Fig.45) cast of aluminium alloy is flanged to the mounting plate of the panel control mechanism. A partition and seat 7 divide the body into two cavities (A and B). The pressure in cavity A is constant and equals 1 kgf/cm^2, while the pressure in cavity B is variable and depends on the compression of spring 14.

Seat 7 carries guide 10 which serves at the same time as a valve. A rubber ring is fitted into the valve disc to ensure sealing. Disc 11 provided with a leather gasket is fastened to the guide upper part. Thus, the setter has two valves, namely, lower (filling) valve formed by seat 7 and guide 10, and upper (bleeding) valve formed by disc 11 and bellows jet 12.

Body 6 is closed from below by cover 9 which also serves as the lower support for spring 8. Bellows 13 provided with jet 12 is secured to upper cover 4 by means of ring 15. The bellows houses spring 14 which rests with one end against jet 12 and with the other end against rod 16. Nut 3 is designed for adjusting the initial tension of spring 14 (i.e. the pressure in cavity B).

Tapper 17 with a supporting ball head is screwed into the rod upper part. Stand 18 fastened directly to the panel control mechanism mounting plate serves as a guide for shaft 2.

Speed Control Servo-Motor

The servo motor is an actuating mechanism which converts the pressure of air supplied from setter cavity B into motion of rod 8 (Fig.46).

The flange of servo-motor aluminium housing 5 attaches cover 1. Clamped between the housing and the cover is diaphragm 2 which transmits the force through disc 3, tapper 14 and a ball and socket hinge to rod 8 linked up with lever 5 (Fig.48c) of the governor remote control mechanism. Displacement of the diaphragm is prevented by spring 12, whose compression is adjusted by means of nut 7. To facilitate rotation of the nut during adjustment, and to avoid twisting of the spring, provision is made for thrust bearing 9.

Air is fed from the setter through a drilling available in cover 1.

Emergency Control Station

The emergency control station (Fig.47) is arranged in the diesel engine stern part, on the main drive housing. The emergency control station is designed to control the engine in case of failure of

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the remote control system or the governor, and also which it is necessary to ensure control directly on the engine.

The control station includes housing 1 and cover 2 cast of aluminium alloy, sleeve 3 with pointer 4 attached to it, lever 5 with handle 6, lock 8 with spring 7, shaft 10, lever 11, bracket 12, gear 13 and worm 14. Lever 11 screwed to shaft 10 is linked up by means of rod 39 (Fig.48a) with lever 37 on lateral shaft 11.

Fine adjustment of speed is carried out with the aid of knob 25 (Fig.47).

The housing lower part mounts a starting valve which consists of body 19, valve 17, control valve 18, relief valve 20, nipple 22, plug 15, springs 16 and 21, and button 23.

Control Shafts, Rods and Levers

The control shafts, rods and levers link up the speed governor, emergency control station and overspeed governor actuating mechanism with the racks of the fuel injection pumps.

Speed governor servo-motor shaft 19 (Fig.54g) is linked up with the fuel injection pump racks through lever 27 (Fig.48a) spring-loaded rod 1, lateral shaft 11, rods 4, 41 and 9. Spring-loaded rod 1 consists of cup 29 connected with bushing 28 which is screwed onto the rod shank, and spring 26. The length of rod 1 can be changed, due to which it is possible to increase or reduce the amount of fuel delivered by the fuel injection pumps.

A lever connects rod 1 to lateral shaft 11 which runs in two ball bearings 10 enclosed in housings. A spring coiled over shaft 11 prevents the latter from turning towards the increase of fuel feed by fuel injection pumps. Levers 3 and 36, and rods 4 and 41 link up the lateral shaft with two rods 9.

Lever 3 is secured to shaft 11 by pin 31 and is connected to rods 4 and 41 by means of stud 30.

Rod 9 is made up of four separate sections interconnected by couplings 7 and pins 25. The coupling houses spring 24 which takes up backlash in the rod joints. Rods 9 move in rollers 18 located in body 8 of the bracket fitted on stud 17. The stud is locked in flange 16 fastened to the diesel engine frame.

Rods 4 and 41 are connected with rods 9 by means of stem 5 which moves in bronze bushings 33 mounted in frame covering body 34. To lubricate stems 5, bodies 34 are provided with pressure lubricators (not shown in the drawing).

Stem 5 is loaded by spring 35. The length of stem 5 can be changed by screwing the connecting shackle into it.

Two carriers 19 and 21 secured on rod 9 and interconnected by pin 20 link up the [illegible] fuel injection pump racks. Located between the carriers is the fuel injection pump rack roller (Fig.27). Spring 22 (Fig.48a) presses carrier 21 to the rack roller. The emergency control station is linked up with the fuel injection pump racks through rod 39, levers 36 and 37, lateral shaft 11, and rods 4, 41 and 9. Bushing 38 allows to adjust the length of rod 39. Rod 42 and lever 40 connect the speed governor actuating mechanism 43 to lateral shaft 11.

Lever 12 is fitted on the diesel engine lateral shaft and is held to it by pin 13. This lever rests against stems 13 of the servo-motor of fuel feed limiter 14, (see also Fig.45b), and limits the turn of the lateral shaft towards the increase of fuel feed during starting or overloading of the engine.

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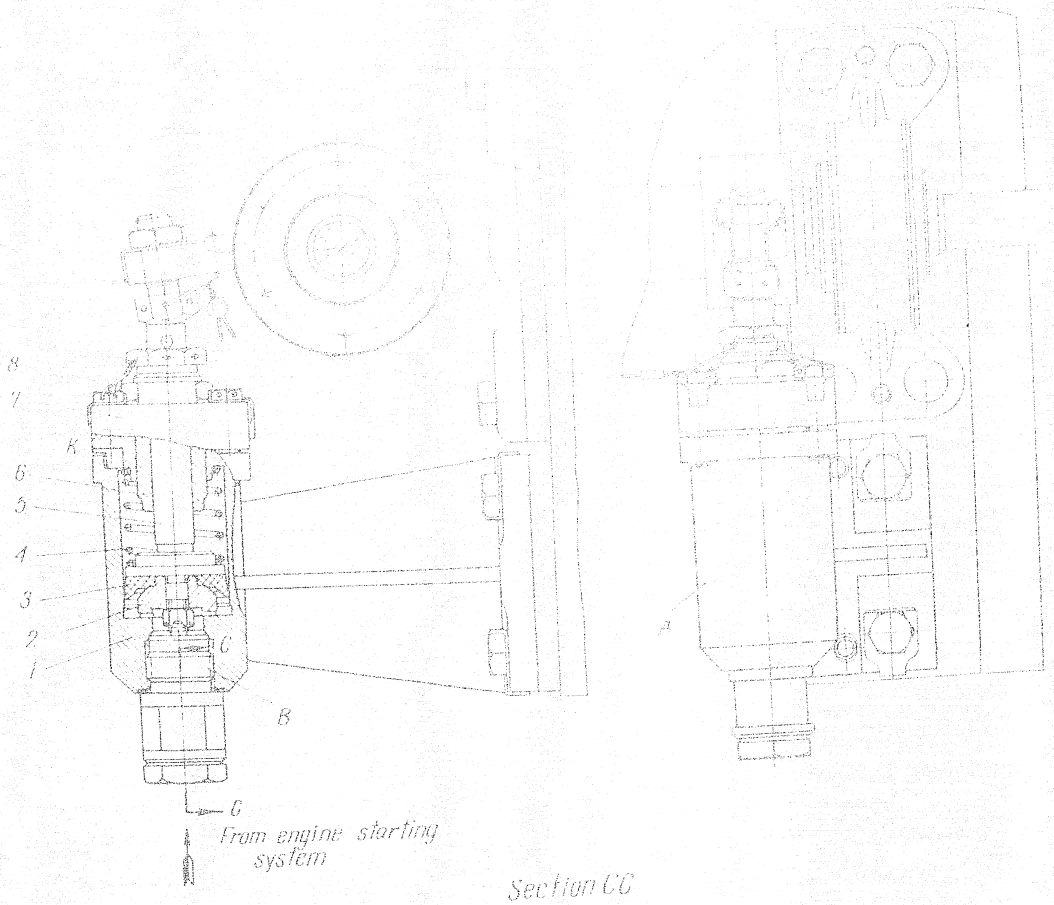

Section CC

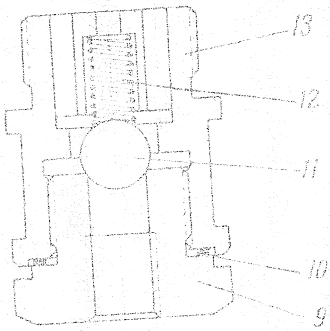

FIG. 46. FUEL FEED LIMITER

1 – body; 2 – stem support; 3 – collar; 4 – spring; 5 – stem; 6 – adjustable stop; 7 – cover; 8 – nut; 9 – pipe union; 10 – gasket; 11 – ball; 12 – spring; 13 – body; A – servo motor; B – throttle valve

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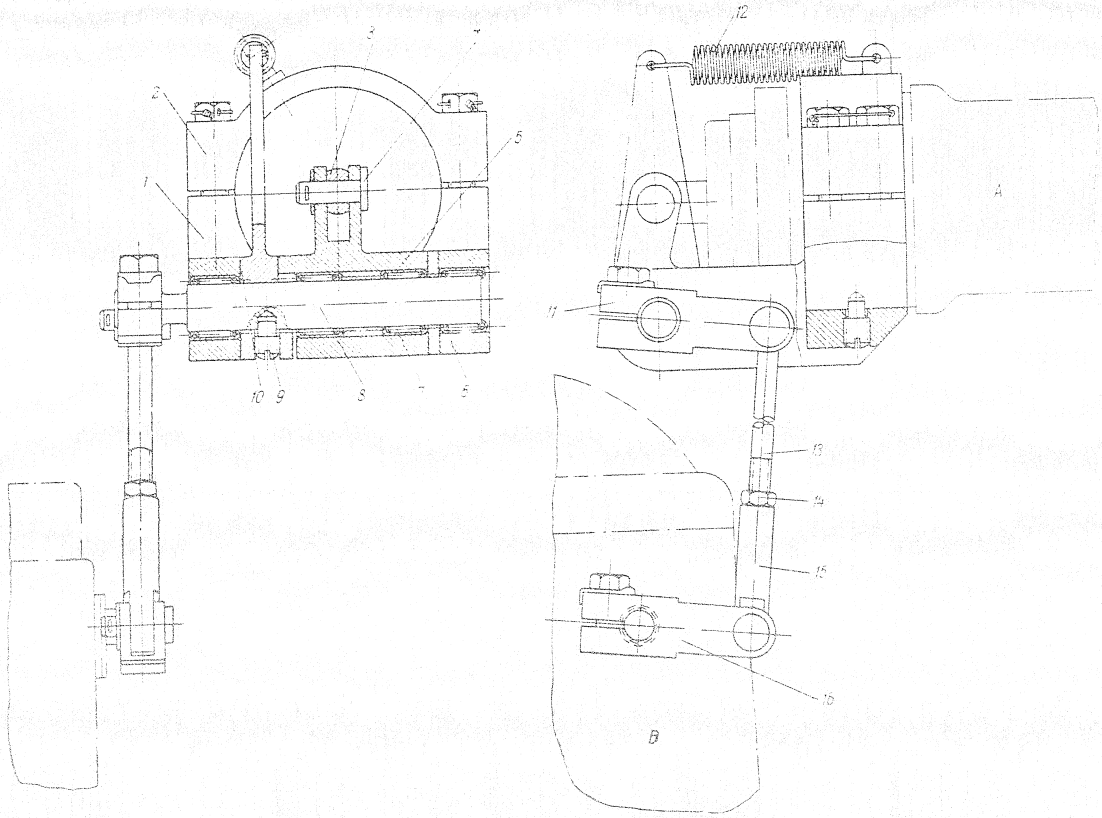

FIG. 49c. GOVERNOR REMOTE CONTROL MECHANISM

1 – bracket; 2 – cover; 3 – servo-motor stem; 4 – pin; 5 – lever; 6, 7 – needle bearings; 8 – shaft; 9 – locking screw; 10 – lever; 11 – lever; 12 – spring; 13 – rod; 14 – locknut; 15 – rod; 16 – speed control lever; A – servo-motor; B – speed governor

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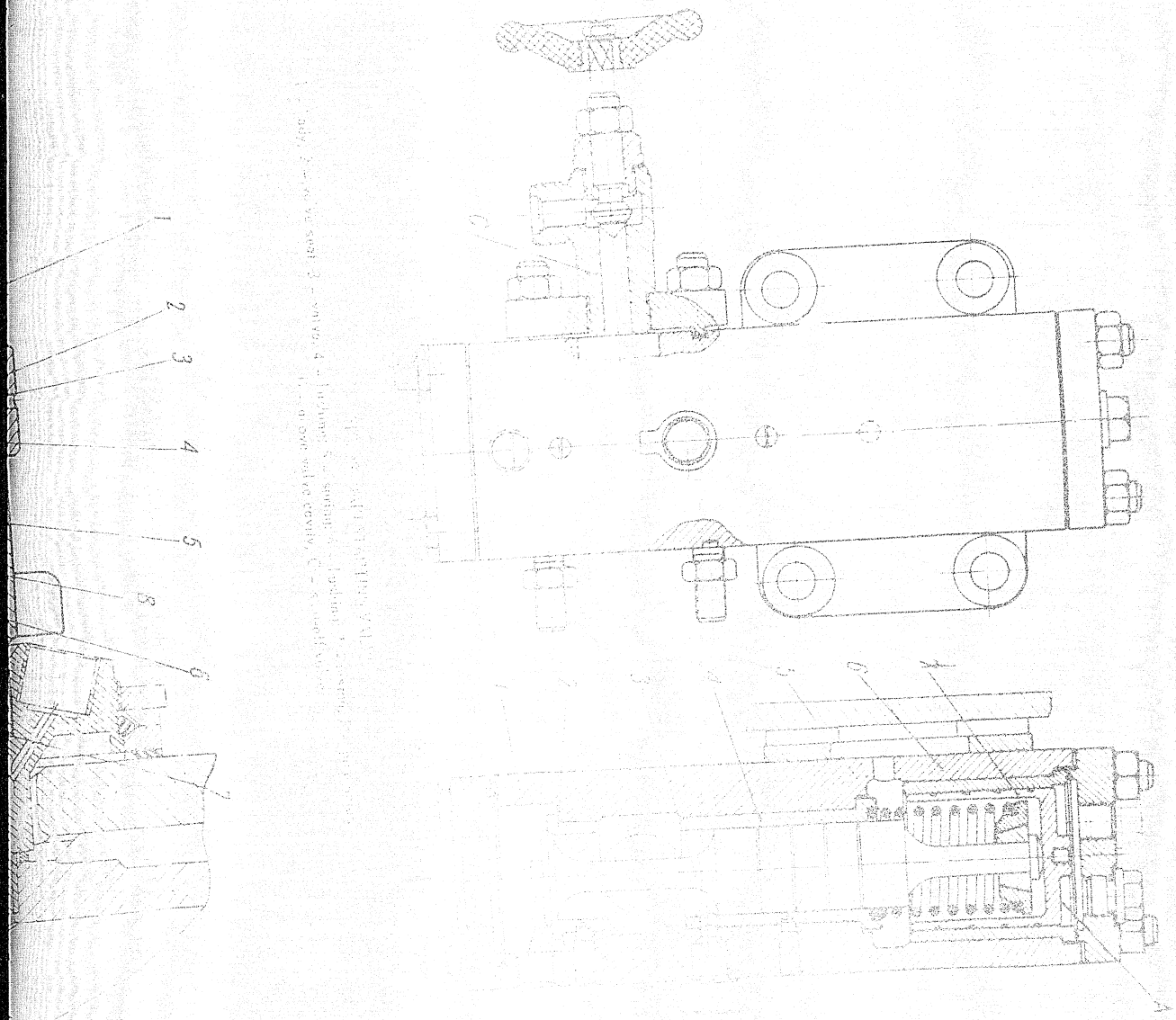

1 – bracket; 2 – cover; 3 – servomotor stem; 4 – pin; 5 – lever; 6 – shaft; 7 – bracket; 8 – lever; 9 – rod; 10 – lever; 11 – rod; 12 – spring; 13 – rod; 14 – locknut; 15 – rod; 16 – speed control lever; A – servomotor

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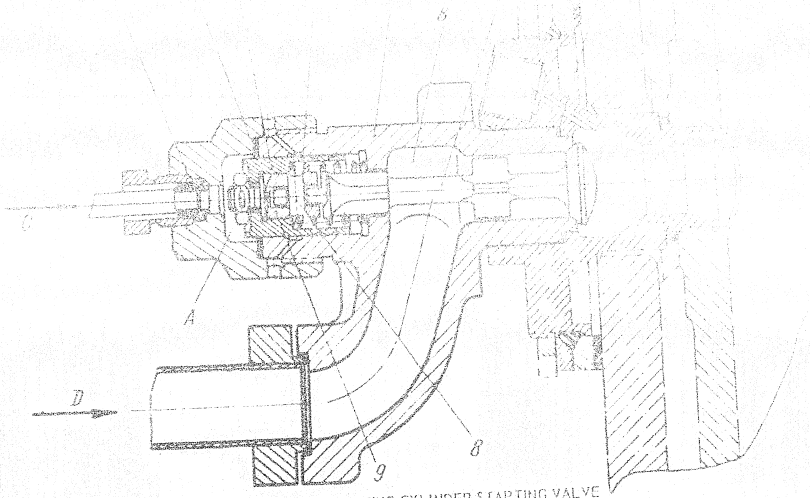

FIG. 50. WORKING CYLINDER STARTING VALVE

1 – nut; 2 – gasket; 3 – piston; 4 – spring; 5 – body; 6 – valve; 7 – gasket; 8 – axle; 9 – valve shunk; A – above-piston cavity; B – under-piston cavity; C – supply of air from air distributor; D – supply of starting air

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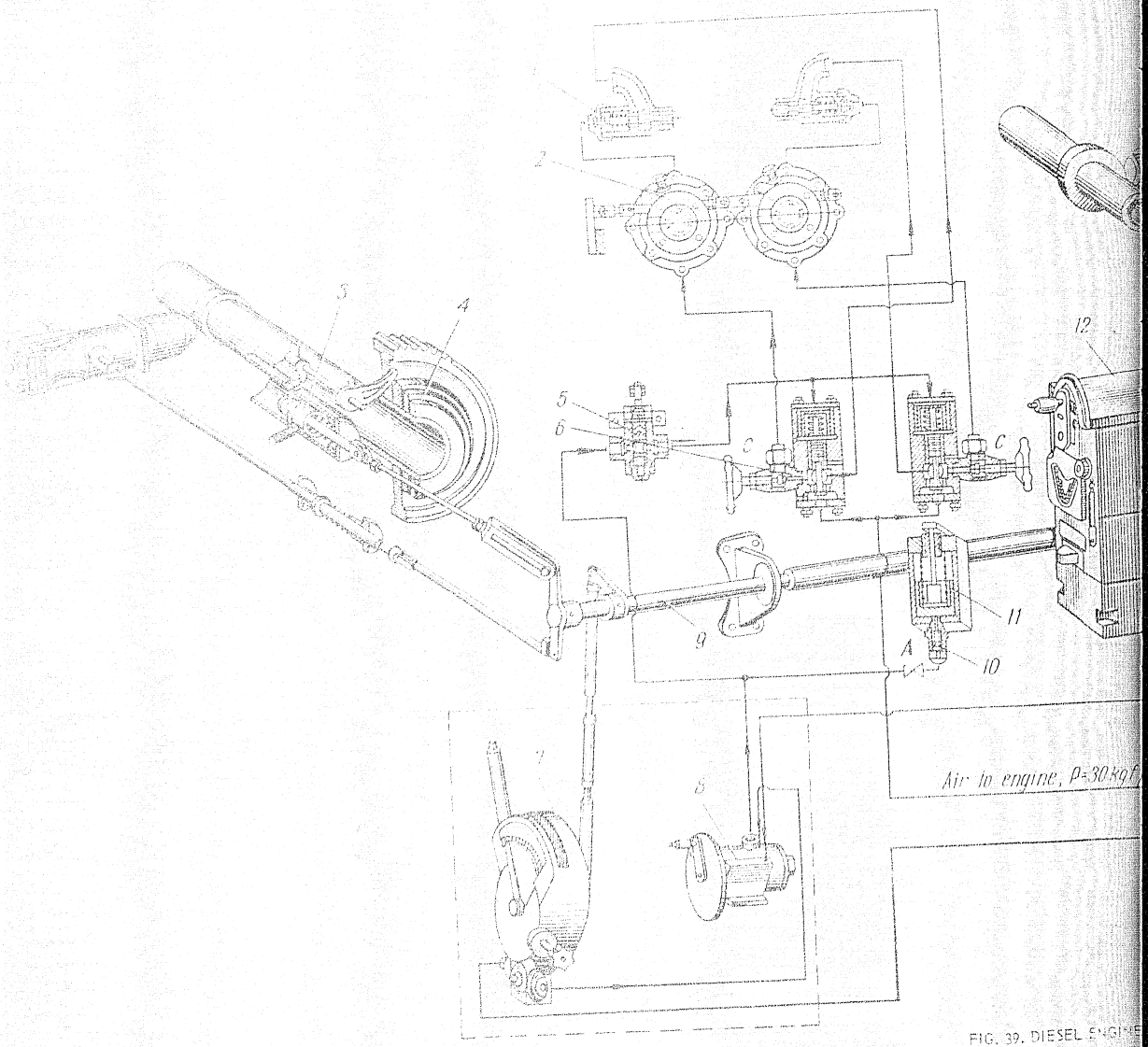

FIG. 39. DIESEL ENGINE

1 – starting valve; 2 – air distributor; 3 – overspeed governor actuating mechanism; 4 – overspeed governor transmitter; 5 – shaft bearing arrangement interlocking slide valve; 6 – main starting valve; 7 – emergency control station; 8 – control selector switch; 9 – lateral shaft of fuel injection pump rack drive; 10 – throttle valve; 11 – fuel feed limiter; 12 – speed governor; 13 – governor remote control mechanism; 14 – speed control servo-motor; 15 – high-press. fuel injection pump; 16 – camshaft; 17 – speed restricting plate; 18 – pneumatic

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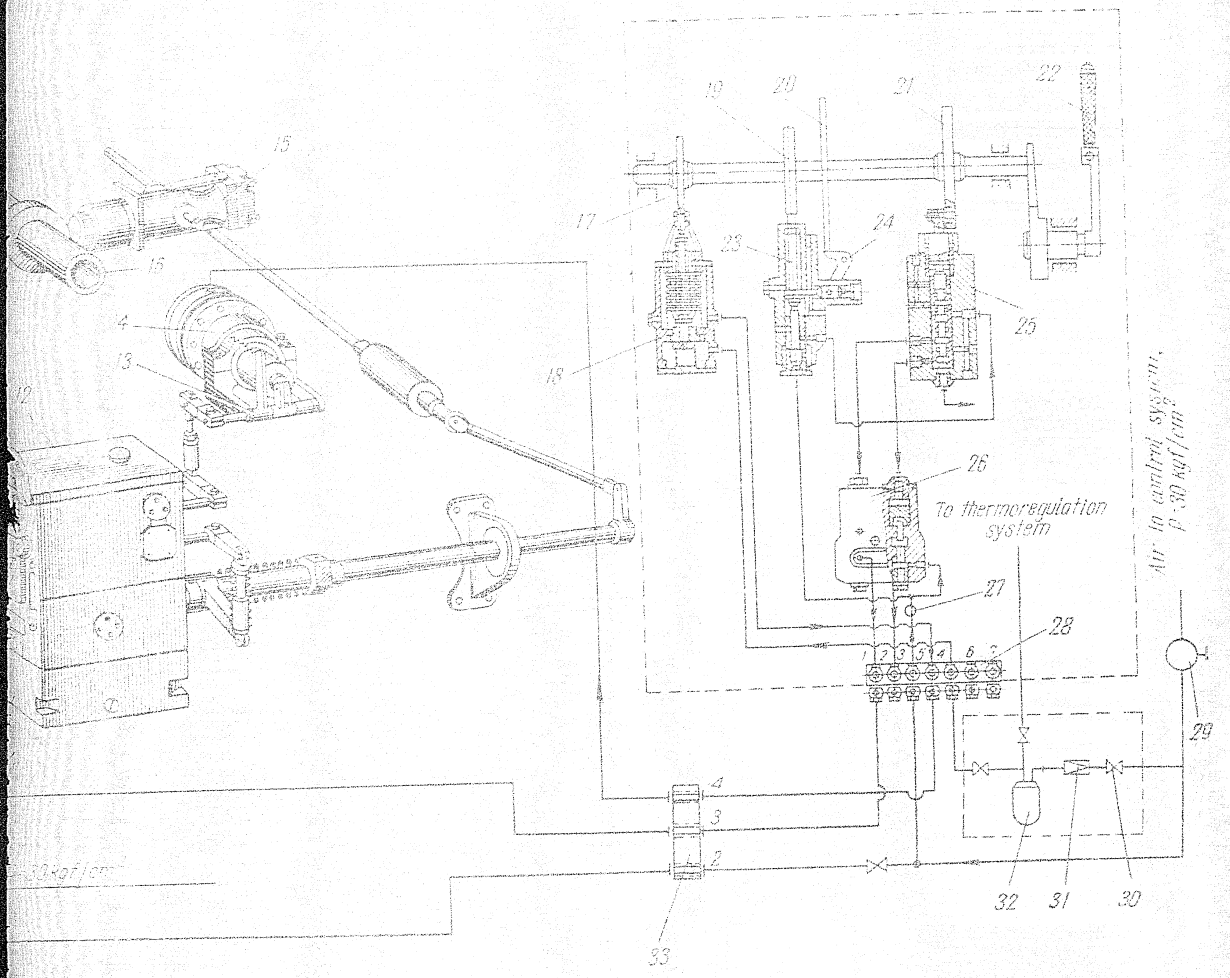

...ENGINE STARTING AND CONTROL DIAGRAM

...letter: 19 – starting valve; 20 – fuel oil pump; 21 – plate of intermediate starting valve slide valve; 22 – ... rod handle; 23 – starting valve; 24 – starting valve lever; 25 – slide valve of intermediate starting valve; 26 – thermodrive starting valve; 27 – crank; 28 – shutdown block; 29 – ... rod; 30 – valve; 31 – rod rod; 32 – buffer cylinder with a capacity of 40 – ... 33 – compressed air tank.

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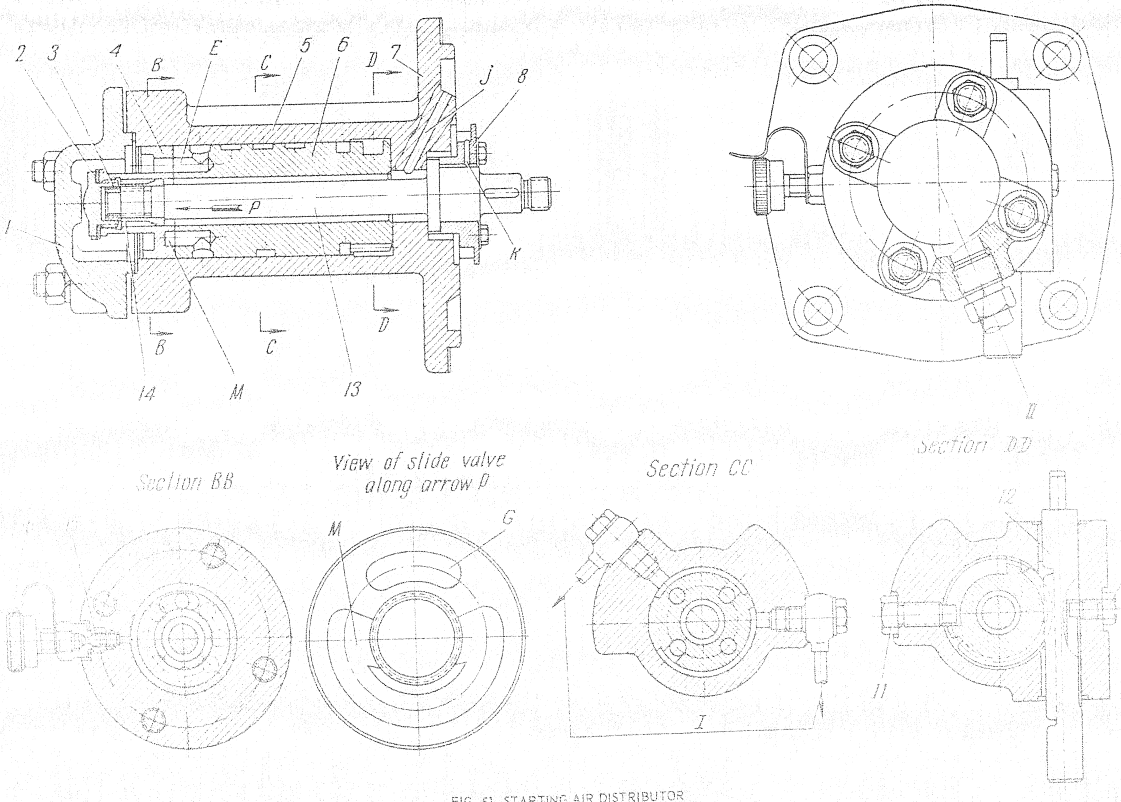

FIG. 51. STARTING AIR DISTRIBUTOR

1 – cover; 2 – bolt; 3 – spring; 4 – slide valve; 5 – housing; 6 – drum; 7 – gasket; 8 – flange; 10 – bolts; 12 – toothed rack; 13 – shaft; 14 – splined bushing; 15 – ball valve; 16 – lubricator; G – slide valve slot; M – slide valve groove; P – air bleed drilling; K – oil supply drilling; I – to starting valve; II – air inlet

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FIG. 51. STARTING AIR DISTRIBUTOR

1 — cover; 2 — nut; 3 — spring; 4 — slide valve; 5 — housing; 6 — drum; 7 — gasket; 8 — flange; 9 — drive gear; 10 — bolt; 11 — bolt; 12 — toothed rack; 13 — shaft; 14 — bushing; 15 — ball valve; 16 — lubricator; G — slide valve slot; M — slide valve groove; J — air feed drilling; K — oil supply groove

cylinder into valve cavity B, but as the pressure of air and the force of spring 3 acting on piston 2 are higher than the air pressure against the disc of valve 6, the valve remains

As soon as air is admitted from the starting air distributor into cavity A above piston 3, valve 6 opens and admits starting air into the cylinder. After the air distributor connects cavity A to atmosphere, the valve actuated by spring 4 occupies its seat, and the supply of air into the engine cylinder ceases.

Starting Air Distributor

The housing of the minor accessories drive (see Fig.14a) mounts two air distributors, each of them designed to operate the starting valves of one cylinder row.

The air distributor consists of cast-iron housing 5 (Fig.51) and cover 1, slide valve 4, drum 6, flange 8, shaft 13, toothed rack 12 and drive gear 9.

Slide valve 4 is engaged with shaft 13 by means of bushing 14 provided with internal and external splines which allow to set the slide valve with regard to drum 6. A lock washer secures nut 2 relative to the slide valve. Spring 3 presses the slide valve off the drum after the air supply ceases. Air is supplied through the pipe union available in cover 1.

Drum 6 is loose-fitted on shaft 13. On the side of the slide valve the drum end face is provided with eight drilled passages I of various depth, which communicate with the grooves cut over the drum outer surface (see section CC). The grooves are connected with pipe unions which admit air to the starting valves.

The drum opposite end carries teeth to engage toothed rack 12. Bolt 10 holds rack 12 against the axis, while bolt 11 prevents the drum from turning. The air distributor toothed rack is secured rigidly in the position of forward travel of drum 6.

Periodic relief of the starting valves during the starting procedure is performed through drum drilled passages E, slide valve groove M, clearance between shaft 13 and drum 6, and through drilled passages J.

After the supply of air to the air distributors ceases, discharge of air from the cylinder starting valves is carried out through drum drilled passages E, end face clearance between slide valve 4 and drum 6 (the slide valve is pressed off by spring 3 as far as cover 1 permits), clearance between shaft 13 and drum 6, and through drilled passages J.

The air distributor shaft bearing is lubricated with oil delivered along groove K. Grease is fed to slide valve 4 through lubricator 16 and ball valve 15.

Control Selector Switch

The control selector switch is used to change over the air supply to the diesel engine starting system members from the remote control panel to the emergency control station or vice versa (when changing over the control from the remote control panel to the emergency control station or from the control station to the panel).

The selector switch is mounted on the main drive housing near the emergency control station.

The control selector switch (Fig.52) comprises bronze housing 6, slide valve 7, covers 1 and 8, and handle 5. Handle 5 is provided with a spring-loaded lock, which allows to secure it in one of the following two positions marked on cover 1: CONTROL PANEL (ПУЛЬТ) or CONTROL STA-

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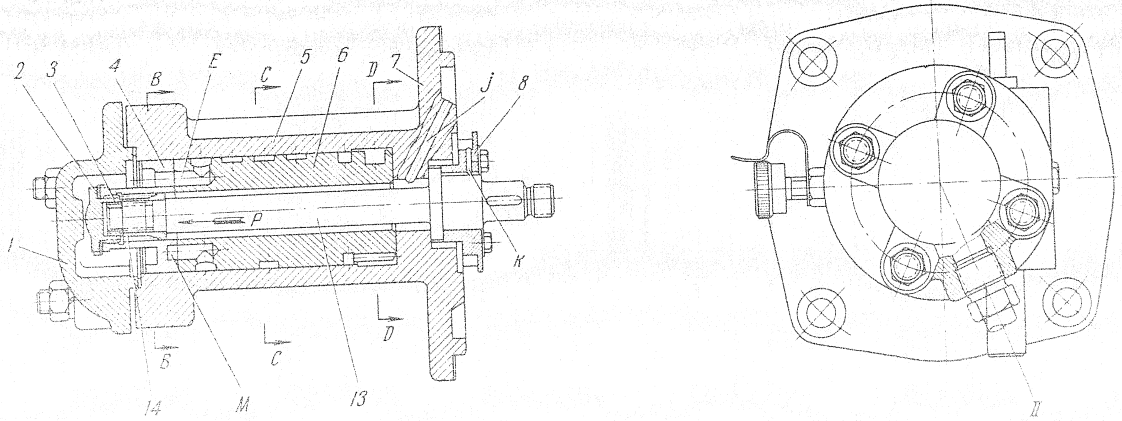

Section BB

View of slide valve along arrow D

Section CC

Section DD

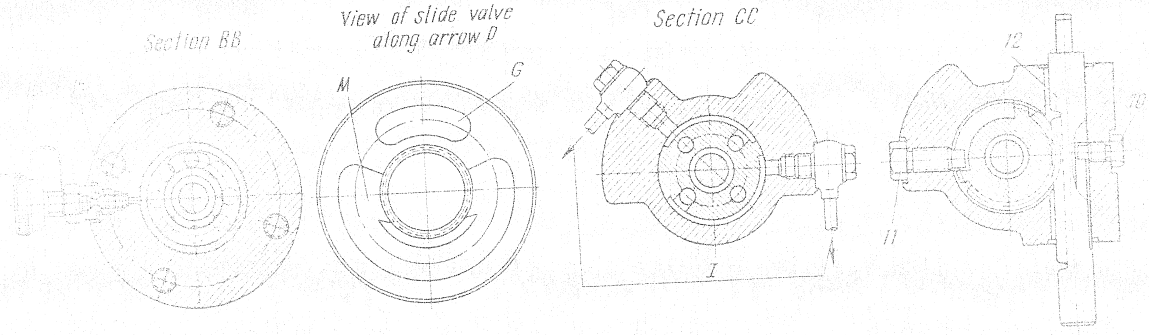

FIG. 51. STARTING AIR DISTRIBUTOR

1 – drum; 2 – valve; 3 – spring; 4 – slide valve; 5 – housing; 6 – drum; 7 – gasket; 8 – flange; 10 – lever; 11 – toothed rack; 13 – shaft; 14 – splined bushing; 15 – ball valve; 16 – lubricator; G – slide valve slot; M – slide valve groove; P – air bleed drilling; K – air supply drilling; I – to starting valve; II – air inlet

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Air goes from the annular cavity into valve cavity B, but as the pressure of air and the force of spring 3 acting on slide valve 4 are greater than the air pressure against the disc of valve 6, the latter remains closed.

As soon as air is admitted from the starting air distributor into cavity A above piston 3, valve 6 opens and admits starting air into the cylinder. After the air distributor connects cavity A to atmosphere, the valve actuated by spring 4 occupies its seat, and the supply of air into the engine cylinder ceases.

Starting Air Distributor

The bearing of the minor accessories drive (see Fig. 54a) mounts two air distributors, each of which is designed to govern the starting valves of one cylinder row.

The air distributor consists of cast-iron housing 5 (Fig. 51) and cover 1, slide valve 4, drum 6, bushing 8, shaft 13, toothed rack 12 and pinion gear 9.

Slide valve 4 is engaged with shaft 13 by means of bushing 14 provided with internal and external splines which allow to set the slide valve with regard to drum 6. A lock washer secures nut 2 relative to the slide valve. Spring 3 presses the slide valve off the drum after the air supply ceases. Air is supplied through the pipe union available in cover 1.

Bronze drum 6 is loose-fitted on shaft 13. On the side of the slide valve the drum end face is provided with eight drilled passages E of various depth, which communicate with the grooves cut over the drum outer surface (see section CC). The grooves are connected with pipe unions which admit air to the starting valves.

The drum opposite end carries teeth to engage toothed rack 12. Bolt 10 holds rack 12 against travel, while bolt 11 prevents the drum from turning. The air distributor toothed rack is secured rigidly in the position of forward travel of drum 6.

Periodic relief of the starting valves during the starting procedure is performed through drum drilled passages E, slide valve groove M, clearance between shaft 13 and drum 6, and through drilled passages J.

After the supply of air to the air distributors ceases, discharge of air from the cylinder starting valves is carried out through drum drilled passages E, end face clearance between slide valve 4 and drum 6 (the slide valve is pressed off by spring 3 as far as cover 1 permits), clearance between shaft 13 and drum 6, and through drilled passages J.

The air distributor shaft bearing is lubricated with oil delivered along groove K. Grease is fed to slide valve 4 through lubricator 16 and ball valve 15.

Control Selector Switch

The control selector switch is used to change over the air supply to the diesel engine starting system members from the remote control panel to the emergency control station or vice versa (when changing over the control from the remote control panel to the emergency control station or from the control station to the panel).

The selector switch is mounted on the main drive housing near the emergency control station.

The control selector switch (Fig. 52) comprises bronze housing 6, slide valve 7, covers 1 and 8, and handle 5. Handle 5 is provided with a spring-loaded lock, which allows to secure it in one of the following two positions marked on cover 1: CONTROL PANEL (ПУЛЬТ) or CONTROL STA-

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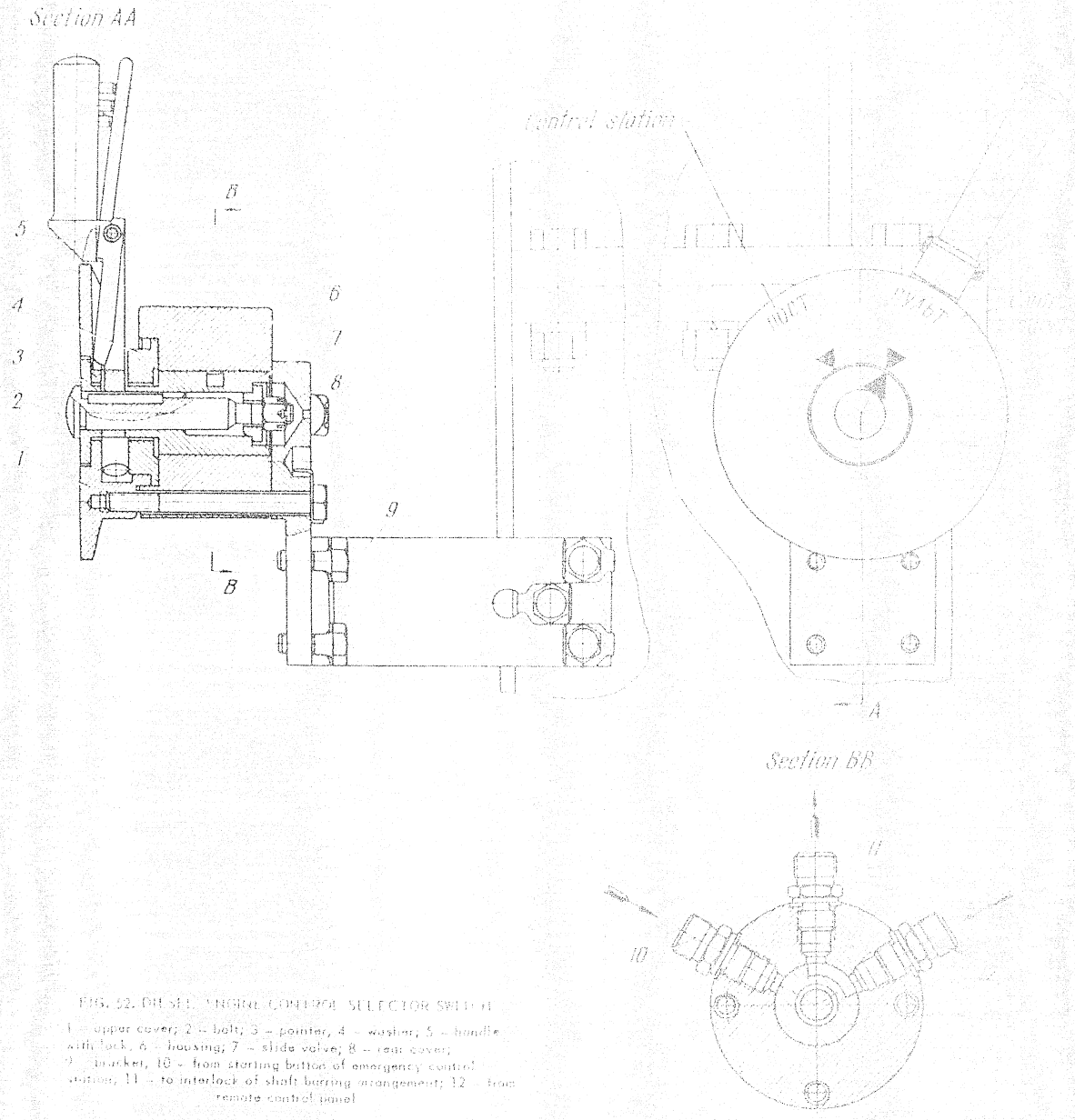

FIG. 52. DIESEL ENGINE CONTROL SELECTOR SWITCH

1 – upper cover; 2 – bolt; 3 – pointer; 4 – washer; 5 – handle with fork; 6 – housing; 7 – slide valve; 8 – rear cover; 9 – bracket; 10 – from starting button of emergency control station; 11 – to interlock of shaft turning arrangement; 12 – from remote control panel

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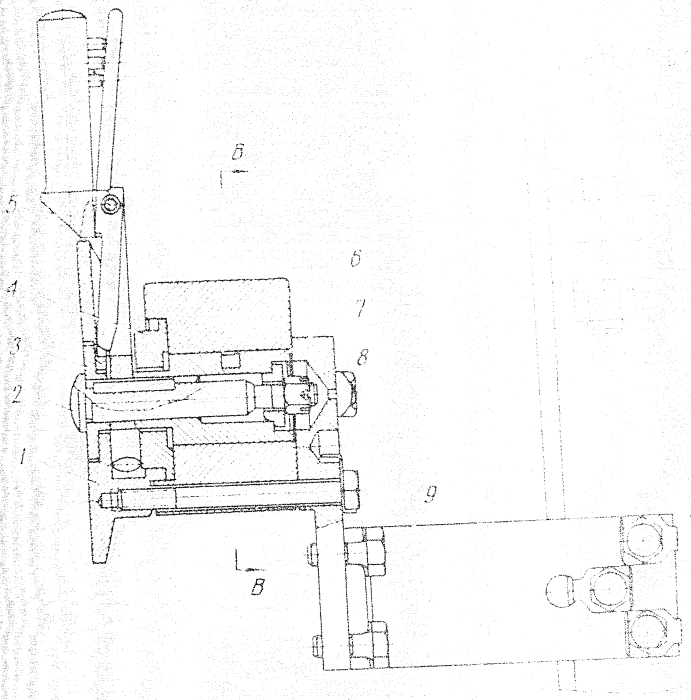
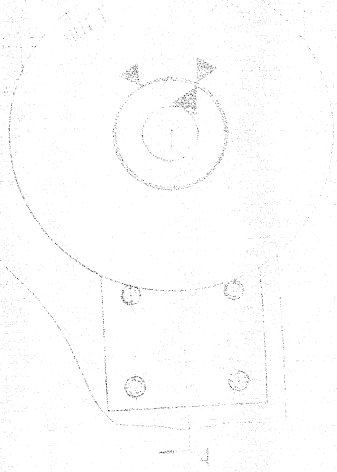
Section AA





Section BB

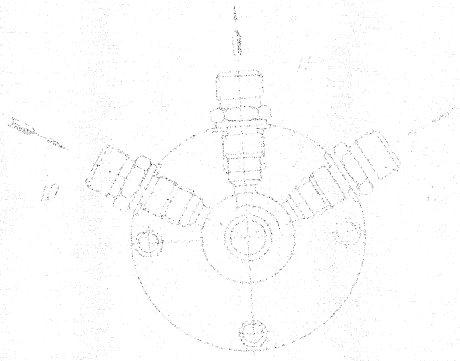


FIG. 52. DIESEL ENGINE CONTROL SELECTOR SWITCH

1 – upper cover, 2 – bolt, 3 – pointer, 4 – washer, 5 – handle with lock, 6 – housing, 7 – slide valve, 8 – rear cover, 9 – bracket, 10 – from starting button of emergency control station, 11 – to interlock of shaft barring arrangement, 12 – from remote control panel

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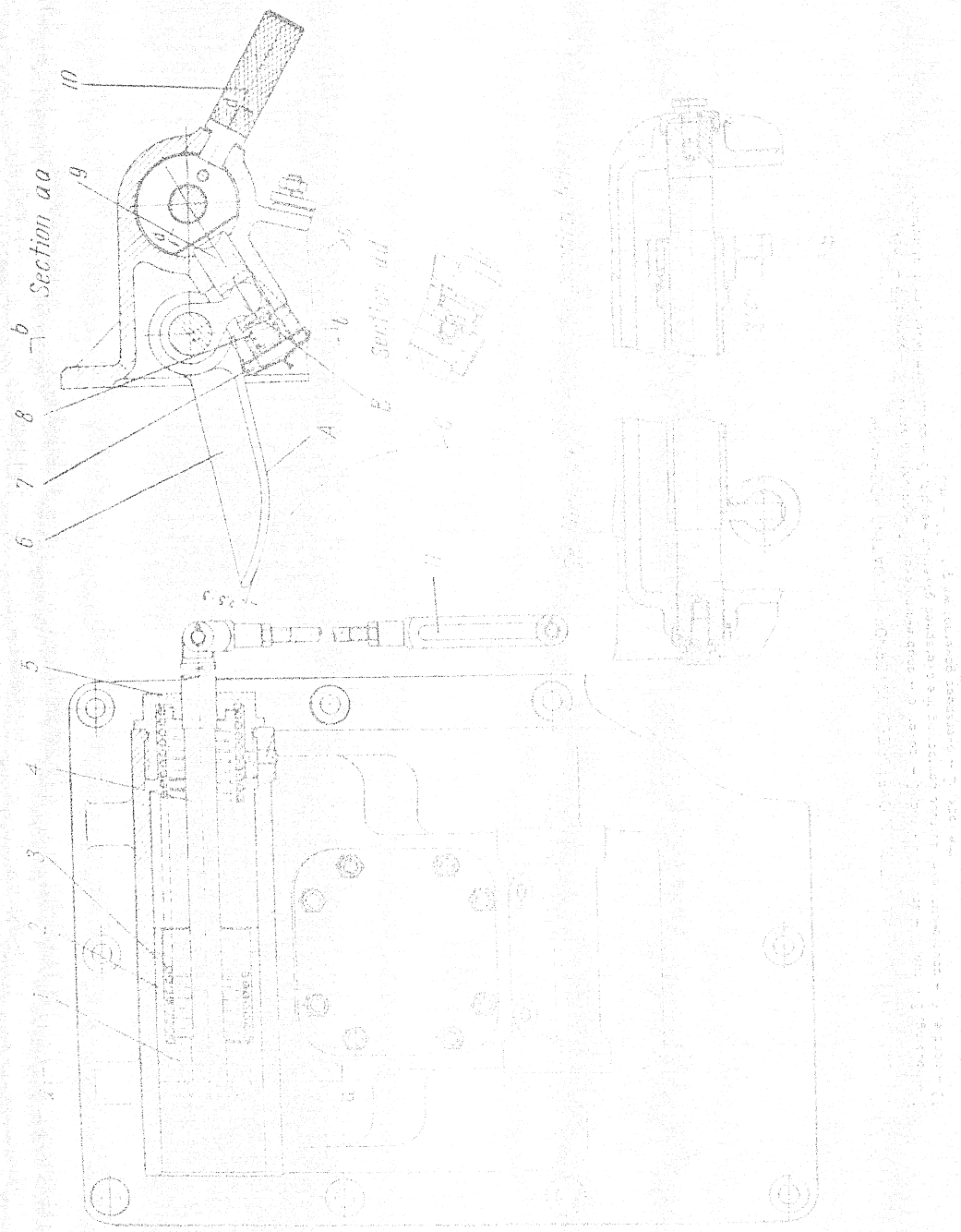

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a. Starting the Diesel Engine from the Cold

When control panel hand[illegible] OPERATION zone, lobe r_4 (Fig.40c) [illegible] the latch of starting valve 23. Then [illegible] starting valve 23, and the latch keeps the valve [illegible] slide valve 25.

During further motion of the [illegible] valve 25 of the intermediate [illegible] valve 25 through slide valve 25 to [illegible] valve 26 and opens the latter. The air delivered from the [illegible] to the control selector switch 8.

If the selector switch handle [illegible] the air passes through the switch and [illegible] opens valve A of fuel [illegible] (Fig.36b) to stop the [illegible].

The rod stroke is adjusted so [illegible] of its full value, the lever of lateral shaft 4 (Fig.36) [illegible] and thus reduces the over-revving during the starting procedure. After the [illegible] the starting valve ball gets into its seat and retains the pressure in the cavity between the [illegible] in the course of several seconds the air escapes gradually through [illegible] returns rod 5 to its initial position in which the diesel engine may [illegible].

During overloading of the diesel engine, rod 5 [illegible] its initial position does not allow the lateral shaft to turn towards the increase of fuel [illegible] engine speed drops herein, and this indicates that the engine is overloaded.

From shaft barring arrangement [illegible] locking shoe valve 5 (Fig.37a) the air is directed to the control pistons of main starting valve 6 and opens the valves, due to which air can be fed from the starting cylinders to air distributors 2 and starting valves 1. The air supplied from the air distributors to the control pistons of starting valves 1 opens the valves. Starting air enters the working cylinders, and the diesel engine starts rotating, with fuel injection pumps 15 cut in by governor 12. After the diesel engine is started, control panel handle 29 is moved to the START zone (or behind division "5" in the OPERATION zone), which is the safety position corresponding the required speed. Lobe r_5 (Fig.40d) of cam plate 20 (Fig.39) releases herein the latch of the starting valve by means of starting valve lever 24. The air pressure and the [illegible] starting valve 23, after which intermediate starting valve 26 closes as well. The supply of starting air to the diesel engine ceases, and air escapes from the engine and control panel [illegible] through the bleeding holes of air distributors 2, starting valve of emergency [illegible] starting valve 26 and starting valve 23.

Air is bled gradually from fuel [illegible] through the throttle valve, and the increase of fuel feed into the cylinders runs also gradually.

The main starting valves are provided with [illegible] which make it possible to start the diesel engine by supplying air into one row of cylinders. [illegible] starting of engine from cold, the supply of air to the throttle valve is shut off [illegible].

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B. Starting the Diesel Engine from the Emergency Control Station

Starting air delivered from the cylinders to the emergency control station (Fig.47) gets into air-supply pipe union 26 and then into cavity B. While valve 17 is held pressed to its seat by spring 19, the air is not admitted further into the starting system. As soon as button 23 is pushed, relief valve 20 presses first upon the rod of control valve 18, which opens, admits some portion of air into the cavity above valve 17, and thus balances the valve. During further pressure upon button 23, valve 17 opens easily and allows air to get into cavity C, whence it flows through pipe union 27 to the control selector switch and further into the diesel engine starting system. After button 23 is released, valves 17 and 18 close. The air remaining above valve 17 is bled out through the hole available in valve 20, while the air from cavity C escapes through the relieving port made in body 1-9).

Further operation of the starting system is similar to that ensured during control from the remote control panel.

C. Changing the Diesel Engine Speed

When control is exercised from the remote control panel, the change of diesel engine speed (Fig. 39) is carried out by means of speed restricting cam plate 17, setter 18, servo-motor 14 and governor 12. The setter is connected to the servo-motor through an air pipeline.

Air at a pressure of 4 kgf/cm^2 is fed to setter cavity A (Fig. 45) and passes through the open lower valve into cavity B, where it acts upon the differential surface formed by the difference in the surface areas of the upper and lower valves.

As soon as the air pressure becomes sufficient enough for overcoming the force of spring 14, guide 10 shifts, the lower valve closes and shuts off the supply of air from cavity A into cavity B.

When the compression of spring 14 lowers down, the pressure of air in cavity B compresses bellows 13, due to which part of air is bled through the upper valve and the drilling of rod 16 into atmosphere (until the strengthening of the spring and the pressure of air get equalized).

Each position of rod 16 corresponds to a definite pressure in setter cavity B and, consequently, to a similar pressure in the above-diaphragm cavity of servo-motor 14 (Fig.39). A change of pressure in the servo-motor above-diaphragm cavity causes a travel of servo-motor rod 8 (Fig.46), and this results in a turn of governor shaft 58 (Fig.54f).

The tension of servo-motor spring 12 (Fig.46) is adjusted so that servo-motor rod 8 starts travelling when the pressure of air against diaphragm 2 is about 1.0 kgf/cm^2. When the control panel handle is in position STOP, the setter shaft presses with its cam against the speed restricting cam plate at the place of the smallest radius, the pressure in setter cavity B obtains herein its minimum value (about 1.2 kgf/cm^2).

In this case, the governor speed regulating handle is in position STOP, and the diesel engine fuel injection pumps will operate in the zero feed position.

When the control handle is moved from position STOP to the first step "0" in the OPERATION zone, shaft 2 (Fig.45) gets pressed down and increases the compression of spring 14, due to which the pressure in setter cavity B rises up to 1.6 kgf/cm^2.

During further shifting the handle to division "0", "1", "2", "3", "4", "5", "6", "7", "8", "9", "10" divisions, the pressure in setter cavity B rises, correspondingly, to 2.0, 2.4, 2.8, 3.2, 3.6, 4.0, 4.4, 4.8, 5.2, 5.6, 6.0 kgf/cm^2. The pressure in servo-motor above-diaphragm cavity increases within a working zone of 1.0 to 5.6 kgf/cm^2, the servo-motor rod turns and turns the governor

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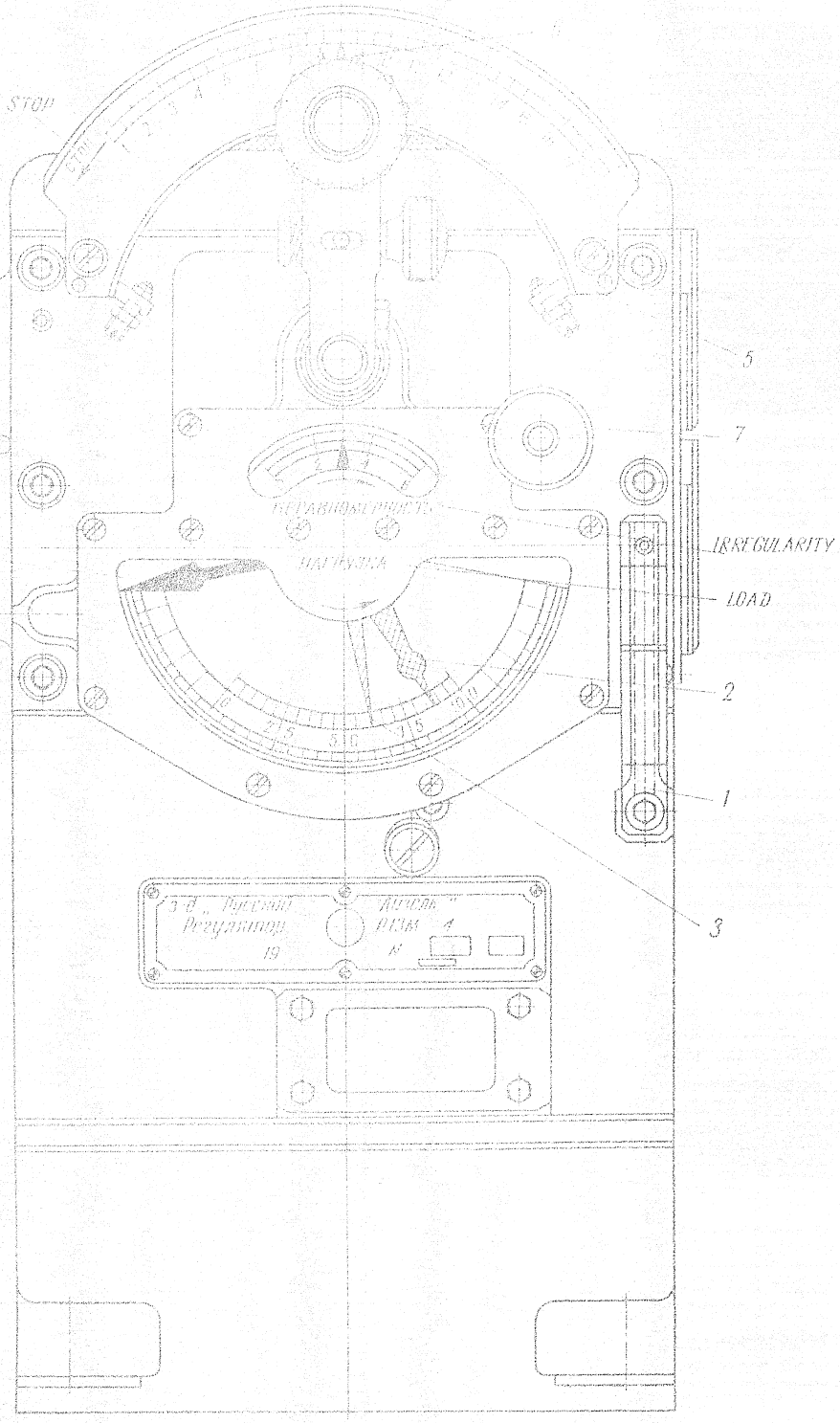

FIG. 51. GOVERNOR RSM-4 (GENERAL VIEW)

1 – oil indicator; 2 – manual load limiter indicator; 3 – automatic load limiter indicator; 4 – load indicator; 5 – speed scale; 6 – speed control handle; 7 – manual load limiter handle

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speed remote control shaft which will set the fuel injection pump racks in a position corresponding to the given r.p.m.

When the control handle is shifted in the opposite direction up to position STOP, the pressure in setter cavity B and, consequently, in the servo-motor, drops down to 1.0 kgf/cm^2. Governor speed control shaft 58 (Fig.54f) actuated by the servo-motor spring turns towards the deceleration of speed until it occupies the zero feed position as soon as the control handle reaches the "0" division in the OPERATION zone.

During further travel of the control handle, the pressure in setter cavity B drops down to its minimum value, but this causes no further turn of the governor speed control shaft (since the servo-motor rod is pressed off by the spring as far as the stop permits).

Hence, each position of the control handle within the OPERATION zone corresponds to a definite speed of the diesel engine.

D. Stopping the Diesel Engine

The diesel engine is stopped by shifting control panel handle 22 (Fig.39) to position STOP. At first, the diesel engine speed gets reduced, since the pressure in cavity B of setter 18 (see also Fig.45) and, consequently, in servo-motor 14, drops down during the travel of the handle towards division "0" in the OPERATION zone. As soon as the pressure in cavity B reaches a value at which the servo-motor spring turns speed remote control shaft 58 (Fig.54f) on governor 12 (Fig.39) to position STOP, the governor sets fuel injection pumps 15 for zero fuel feed.

When handle 22 is moved from the beginning of zone START to position STOP, lobe r_6 (Fig.40d) of cam plate 19 (Fig.39) opens starting valve 23. Before the valve opens, cam plate 21 will shift slide valve 25 to the intermediate position (the slide valve tappet roller moves from lobe r_2 or r_3 to lobe r_1 (Fig.40d) and, therefore, no air will get into the working cylinders.

By the moment the handle is set in position STOP, lobe r_4 of cam plate 20 (Fig.39) will release the latch of starting valve 23 by means of lever 24, and the valve will close.

SPEED GOVERNOR

General

The PTBM-4 (Figs 54a, 54b, 54c, 54d, 54e, 54f, 54g) is a precision, variable-speed, centrifugal, indirect-acting governor with a hydraulic servo-motor, isodrome and rigid feedbacks.

As to its design, the governor is an independent unit with a closed hydraulic (oil) system. The governor is installed with its lower flange on the mounting pad of the intermediate accessories drive unit and is rotated by this drive through a vertical driving shaft provided with a splined end.

Connection of the governor to the fuel injection pumps is carried out through the governor servo-motor shaft splined end extended to the box rear wall.

Connection of the governor to servo-motor 14 (Fig.39) is executed through the speed control shaft splined end extended to the box rear wall by means of the remote control mechanism. The servo-motor is in its turn connected pneumatically to the remote control panel.

The diesel engine speed changes proportionally to the angle of turn of the above splined shaft. Stopping of engine is also done through the speed control by the governor.

The governor is provided with a mechanism for changing the rate of irregularity during engine operation and without load (stator).

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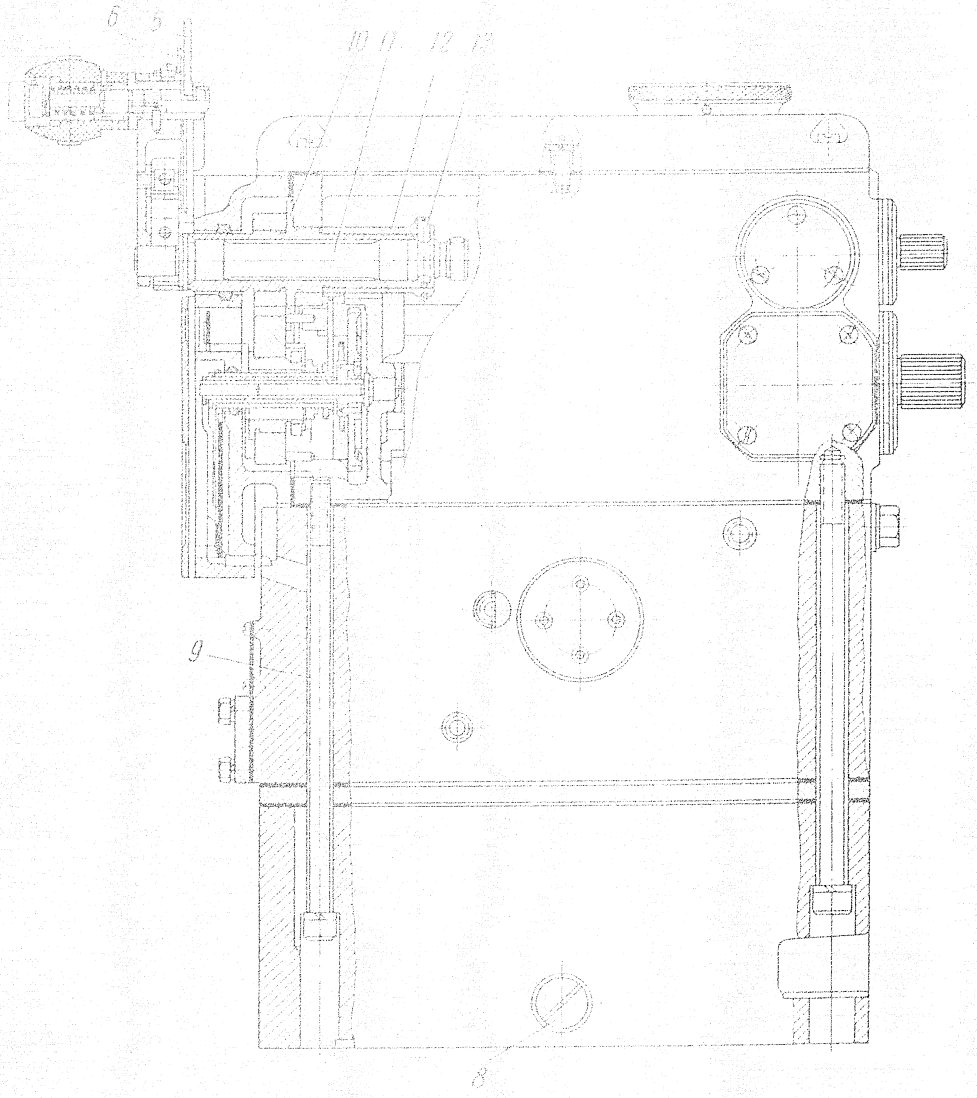

FIG. 54b. GOVERNOR P129M-4 (SIDE VIEW)

5 – speed scale; 6 – speed indicator; 8 – plug; 9 – bolt; 10 – bearing; 11 – speed control handle shaft; 12 – toothed sector; 13 – pin

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The mechanism used for changing the rate of irregularity allows to set the latter within 0 to 6 per cent. The working range for this particular engine is 4 to 6 per cent.

The load limiter serves for protecting the diesel engine against overloads in fuel feed. The load may be limited manually or automatically.

The automatic load limiter connected to the speed control mechanism maintains constant limit of load, depending on the position of the handle on the speed scale. The automatic limiter is equipped with indicator 3 (Fig.54a) which shows the load limit set by the limiter.

Adjustment by means of the manual limiter is done by turning (manually) handle 7 located on the governor face wall.

The position occupied by the manual load limiter is shown by pointer (indicator) 2 on the scale. The range of load limits adjusted manually is within 25 to 110 per cent.

Both limiters are mounted independently, but that which is set for a lower load limit will operate first.

The manual and automatic load limiter indicators are located on the scale concentric with the scale of load indicator 4 (Fig.54a).

Here, as well as during further description, notion "load" will be considered conditionally; in fact, the load indicator shows directly the position of the fuel injection pump feed controls, hence it indicates the value of diesel engine load only indirectly. Therefore, the load limiters serve at the same time as fuel feed limiters.

The level of oil in the governor is checked by means of an oil level indicator fitted on the face side of the governor housing.

An oil priming hole closed with a plug is available in the upper cover.

The lower part of the governor side walls carries two drain plugs 8 (Fig.54b); free access to one of the plugs must be provided during installation of the governor on the diesel engine.

Main Specifications

Model	P13M-4
Type	variable-speed, centrifugal, indirect-action, with hydraulic servo-motor, isodrome and rigid feedbacks, and with remaining irregularity rate adjusted during operation
Speed of driving shaft at rated speed of diesel engine, r.p.m.	1,092
Working angle of servo-motor shaft turn from 0 to 100%, deg	20
Remote control shaft angle of turn from minimum to rated, deg	34.5
Maximum temperature of oil in governor at ambient temperature of 25°C, °C	55
Oil pressure in delivery pipeline, kg/cm²	6 to 8.5
Amount of oil in governor, kg	4
Dry weight of governor, kg	73

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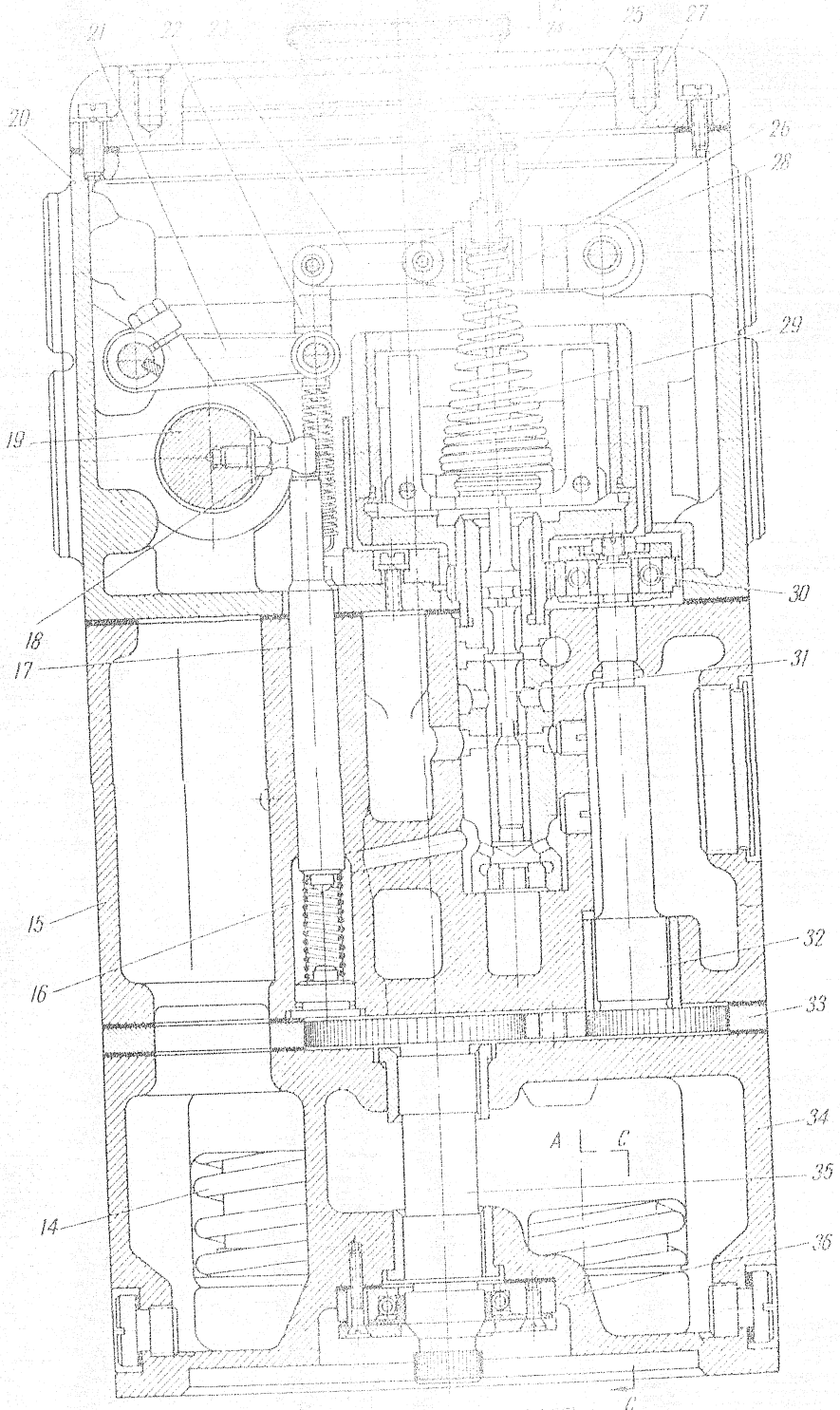

FIG. 54c. GOVERNOR PUMP (SECTIONED)

14 – spring; 15 – housing; 16 – spring; 17 – [illegible] 18 – pin; 19 – servomotor shaft; 20 – box; 21 – feedback lever; 22 – shoe pin; 23 – [illegible] 24 – plug; 25 – upper holder; 26 – coupling; 27 – upper cover; 28 – carriage; 29 – spring; 30 – plunger bushing; 31 – slide valve; 32 – shaft; 33 – plate; 34 – housing base; 35 – sectioned shaft; 36 – oil seal

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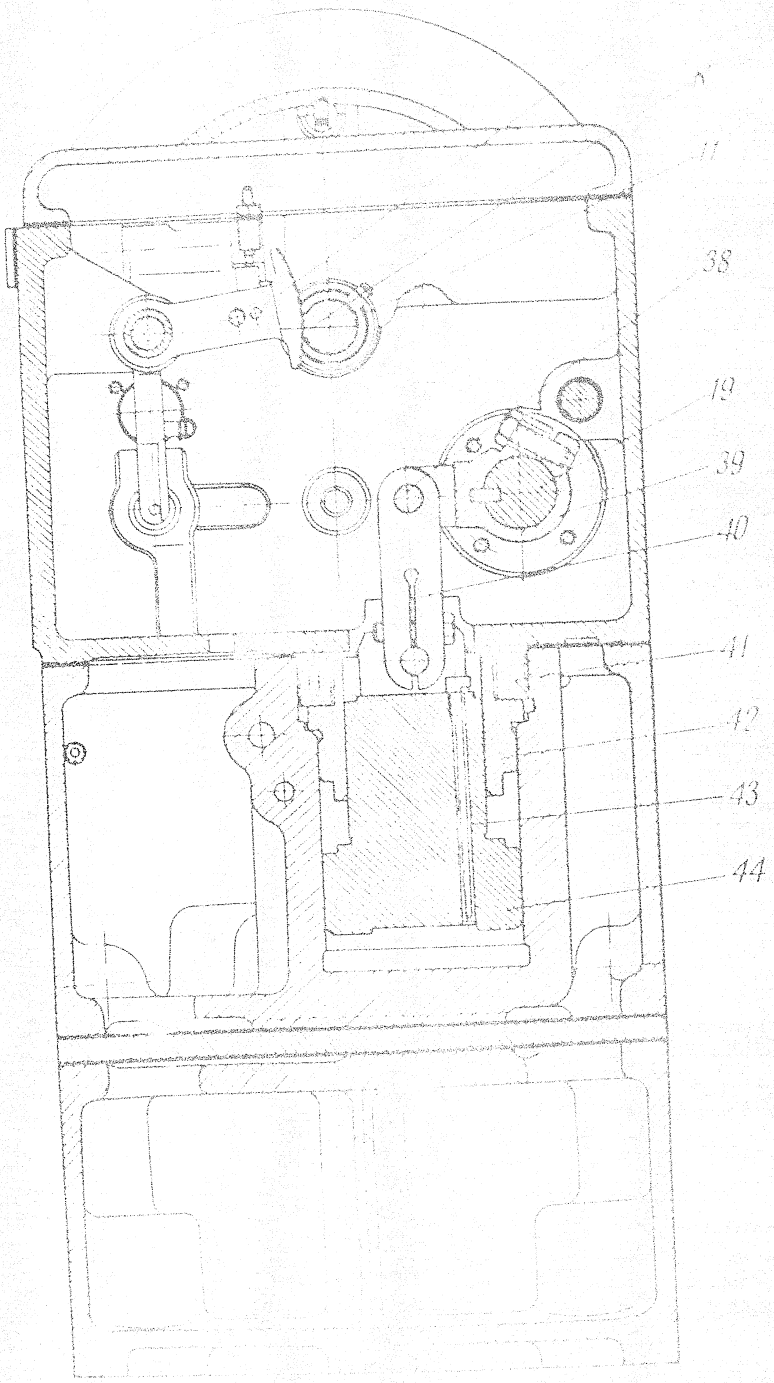

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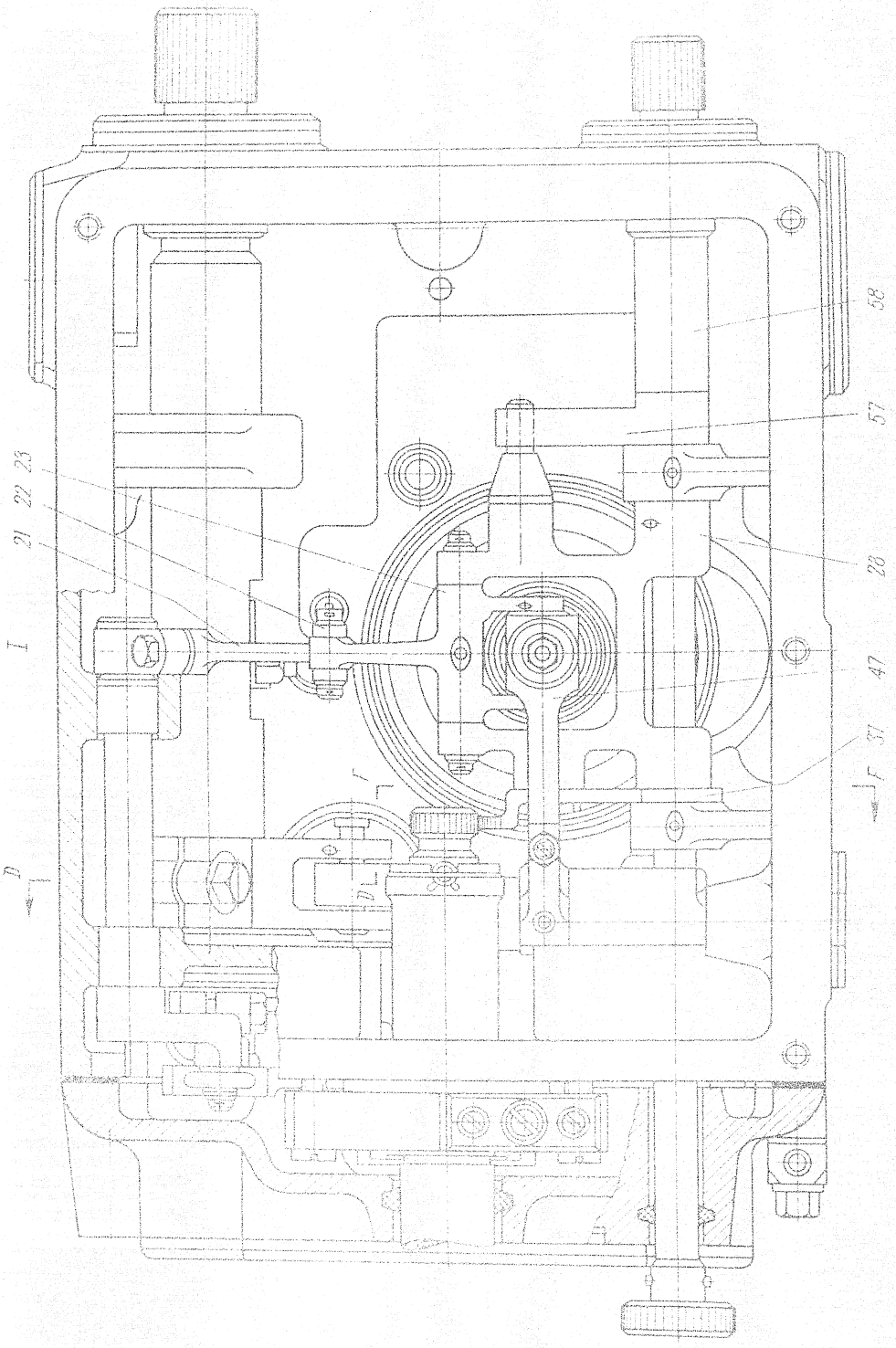

FIG. 5A1 CONTROL PANEL VIEW ALONG ARROW B

21 – knob, 22 – knob, 23 – knob, 28 – carriage, 37 – locking sector, 47 – forked lever, 57 – lever, 58 – shaft)
(I – viewing arrow B (with cover removed)

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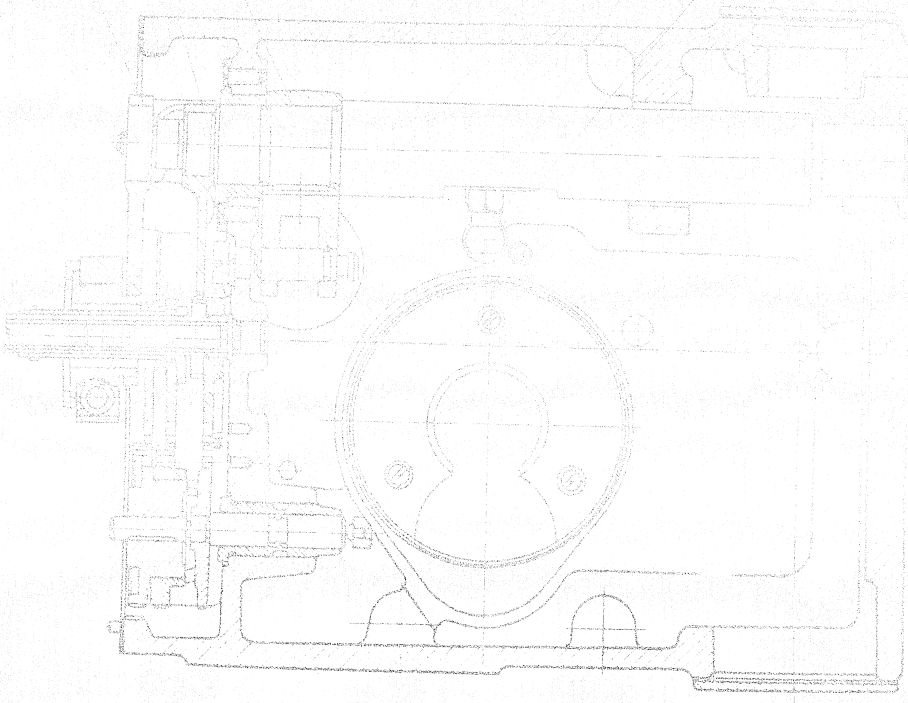

FIG. 54g. GOVERNOR P13M-4 (SECTION THROUGH II)

18 – isodrome pin; 19 – servo-motor shaft; 38 – axle; 39 – lever; 59 – connecting rod; 60 – sector

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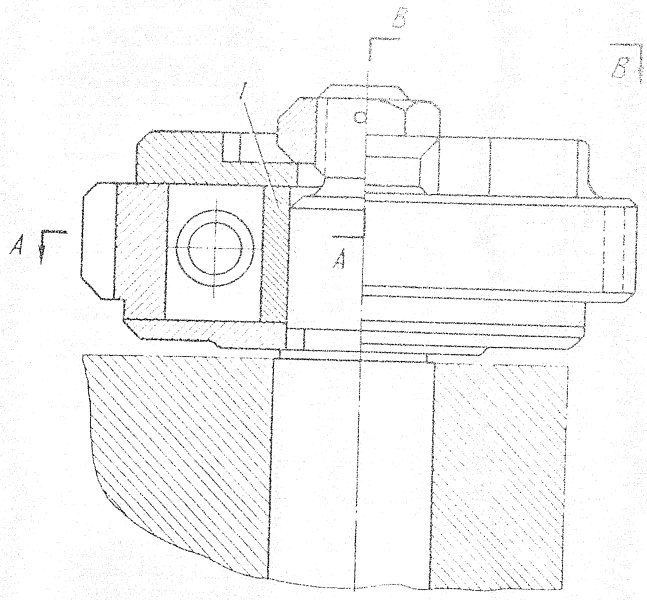
Governor Design

Drive and Oil Pump

The drive intended to transmit rotation from the diesel engine crankshafts to the governor speed-change sensor is combined into one unit with a gear-driven oil pump which forces oil from the governor drain cavity into the delivery pipeline. This ensures independent oil supply of the governor.



Section AA-BB

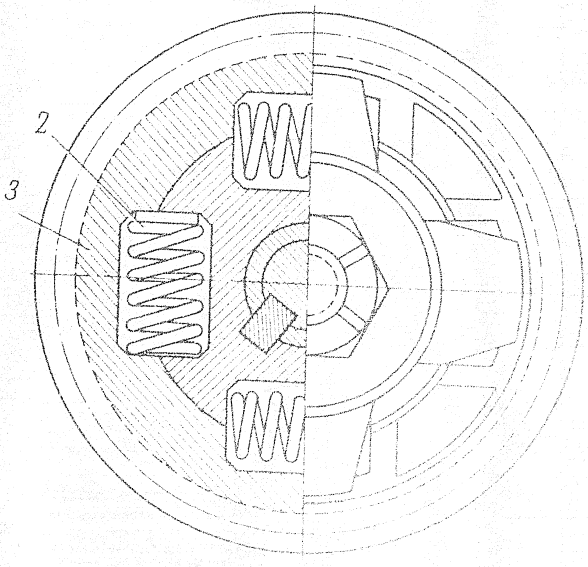


FIG. 55. ELASTIC COUPLING
1 — sprocket, 2 — springs, 3 — gear

Rotation to the speed-change sensor is transmitted from the outer splined end of shaft 35 (Fig.54c) by means of a gear made integral with it, through pinion-shaft 32, to elastic coupling 30 (see also Fig.55) mounted on its upper end.

The intermediate drive elastic coupling (Fig.55) is built into gear 3 whose hub (made in the form of sprocket 1) is rigidly connected to the gear toothed rim by means of four coil springs 2 fitted with a pre-loading into the rectangular ports formed by the sprocket and the gear rim.

The oil pump is formed by the gears of shafts 35 and 32 (Fig.54c), both gears are located in the bores of housing plate 33. To ensure normal operation of the pump, regardless of the direction of its rotation, the pump suction and delivery cavities are closed by four ball valves 55 (Fig.54c).

The pump forces oil into the delivery pipeline which communicates with the accumulator cavity, with the ports of the speed-change sensor slide valve sleeve, and with the servo-motor upper cavity (Fig.56).

The outer end of shaft 35 (Fig.54c) is sealed by means of oil seal 36 provided with a leather cup, to prevent leakage of oil from the governor housing.

Pressure accumulator. The accumulator serves for maintaining constant pressure in the governor delivery pipeline during operation.

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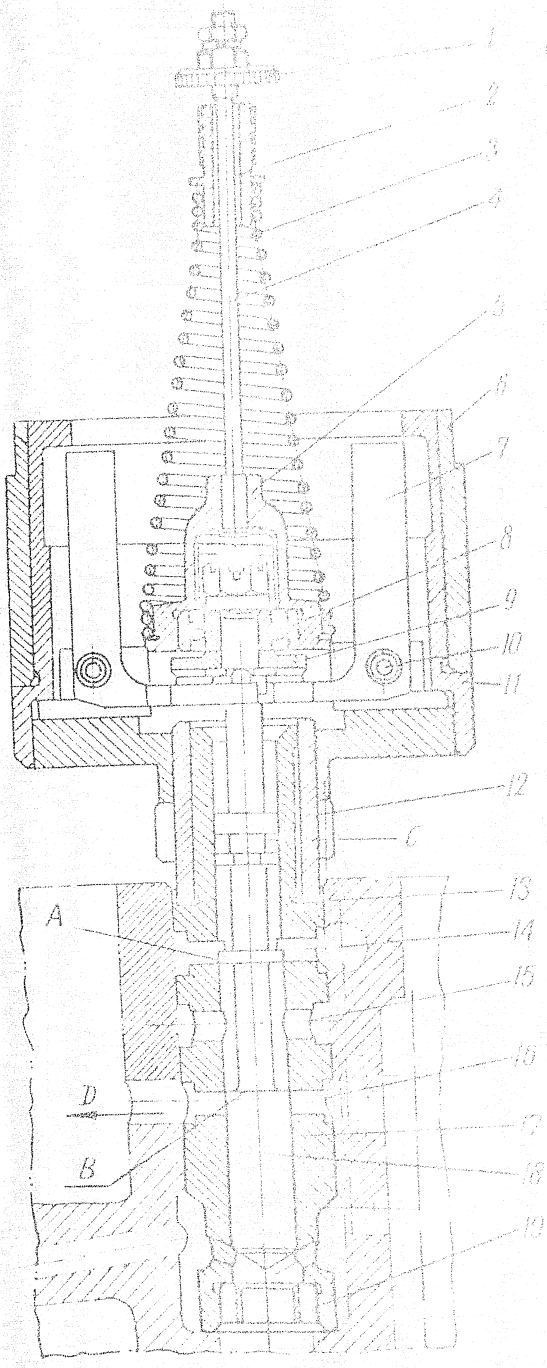

FIG. 57. SPEED-CHANGE SENSOR

1 – thrust plate; 2 – spring upper holder; 3 – conical spring; 4 – spring lower holder; 5 – vibration damper; 7 – weight; 8 – ball bearing; 9 – thrust washer; 10 – axle; 11 – cup; 12 – axle; 13 – floating washer; 14 – upper row of ports; 15 – control passage; 16 – lower row of ports; 17 – plate valve bushing; 18 – valve; 19 – threaded ring; A – plate valve upper holes; B – plate valve lower holes; C – lubrication hole; D – drain hole.

The accumulator (Fig.54) consists of two similar pistons 31 provided with spring packs inside and fitted in the bores of the governor housing and base.

In the governor functioning diagram (Fig.56) the governor is shown with one piston and one spring, to simplify the drawing.

When in working position, the accumulator pistons are balanced by the forces of oil pressure in the delivery pipeline of one stage and by the forces of springs on the other side. The accumulator pistons partially close the return bleeding hole A (Fig.56) which communicates with the governor housing drain cavity.

The pressure in the governor delivery pipeline is maintained actually constant due to the variation in the opening of the bleeding hole.

To ensure safe and convenient mounting, accumulator springs 30 and 30a (Fig.54c) are compressed preliminarily into a pack which comprises a guide screwed up to upper plate 31 by means of pin 32 inserted into rod 33.

The speed-change sensor responds to the deviation of diesel engine speed from its rated value, actuates the governor manually, and causes operation of the governor mechanism which controls the fuel feed of the fuel injection pump.

When the speed starts changing from the [illegible] value, the governor [illegible] changes the fuel [illegible] of the fuel injection pump [illegible]

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of governor. Weights 7 rest on

10 and secured on the

the weights tend to re-

which is transmitted

sleeve 6. The higher the force of

Consequently, the speed of cup 11 with

optimize the force of spring 3. Hence, the va-

speed of the diesel engine. This property is

control mechanism and

end face of spring 3.

Upper holder 2 of spring 3 has a threaded end for connecting to the speed control mechanism and

changing the spring preliminary compression. Rod 4 passing through the hole made in upper holder 2

is pressed into lower holder 5. Screwed on the end of rod 4 is thrust plate 1 used to tighten slide

valve 18 upwards, when stopping, or when limiting the load.

For the compression of conical spring 3, its more pliable coils contact each other gradually and

have elastic properties. The variable rate of coiling is set so as to obtain the spring characte-

ristic which would ensure proportional relation between the deflection of spring 3 and the speed.

Thrust washer 9 is fastened to the slide valve upper end and, therefore, when weights 7 swing on

their axles 10, slide valve 18 travels along its axis together with thrust washer 9. The slide valve is

hollow and has a plug soldered into its lower part.

Slide valve bushing 17 pressed into the governor housing has three rows of ports, two ports in

each row. Both upper 14 and lower 16 rows of ports are of rectangular section; the upper row of ports

communicates with the delivery pipeline, while the lower row of ports communicate with the drain ca-

vity of the governor housing. Intermediate row of ports is of round section; it communicates with the

control passage 15 and further with the servo-motor.

The pressure produced in the control passage, hence the motion (or equilibrium) of the servo-

motor, depend on the position of slide valve 18. When in equilibrium position, slide valve helices A

and B overlap upper 14 and lower 16 rows of ports. In this case, some pressure intermediate between

the pressure in the delivery pipeline and in the drain cavity is produced in the control passage, and the

servo-motor appears to be in equilibrium. As soon as the slide valve departs up or down from equili-

brium position, the control passage communicates with the delivery pipeline or drain hole, and the

servo-motor starts its motion in the respective direction.

The slide valve bushing central hole communicates from below with the isodromo passage. The

outer surface of the slide valve bushing upper part serves as a support (bearing) for cup 11 of the

speed change sensor. The bearing is lubricated with oil fed through lubricating hole C made in the

slide valve bushing. To carry the axial force more reliably, floating washer 13 is fitted on the slide

valve bushing between the gear and the shoulder. Threaded ring 19 serves for pressing the bushing out.

Speed control mechanism. As already said above, the speed is controlled by changing the position

of the upper end face of the speed change sensor spring. The control mechanism is designed to actuate

the governor from the control panel by means of the pneumatic remote control system, or by means of

the handle extended to the front cover (in case control is exercised from the emergency control sta-

tion on the diesel engine).

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The control mechanism consists mainly of a lever-type summating mechanism, a remote control shaft, and a control handle with a speed indicator.

The lever-type summating mechanism (Figs 56 and 54c) comprises carriage 28, fork 23, slide 22, feedback lever 21, and coupling 26 with a slot and a locking screw; upper holder 25 of speed-change sensor spring 29 is screwed into the coupling. Speed-change sensor spring 29 carries the total force caused by the turn of carriage 28 which controls the speed, and of lever 21 which controls feedback from the servo-motor piston to the speed-change sensor. Carriage 28 (Fig.54c) is hinged on

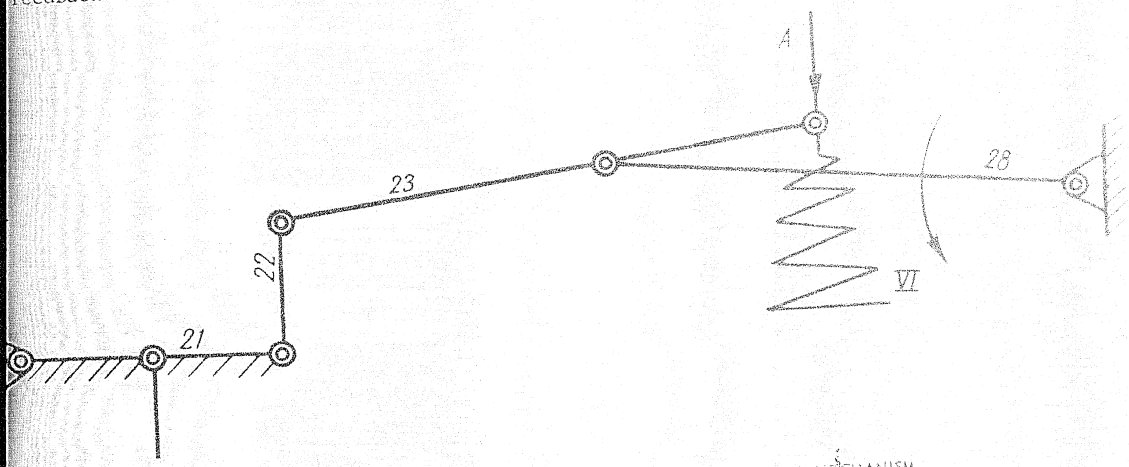

FIG. 58. DIAGRAM OF SUMMATING LEVER-TYPE SPEED CONTROL MECHANISM
A — motion towards the increase of speed

one side to lever 57 secured on remote control shaft 58, and on the other side it is connected to the speed indicator through toothed sector 37.

The remote control shaft located lengthwise the governor has a splined end extended to the rear wall of the mechanism box. This splined end serves for connection (through a leverage) to the remote control pneumatic servo-motor. Speed control handle shaft 11 (Fig.54b) with a gear cut on its end runs in bearing 10 and drives (by means of its pin 13) automatic load limiting toothed sector 12 fitted on the bearing. The diesel engine speed readings in arbitrary units are indicated on scale 5 (Fig.54a).

Servo-motor and servo-motor shaft. The servo-motor operated by the speed-change sensor slide valve produces (on the account of oil pressure) the forces necessary for changing the position of controls which govern the amount of fuel delivered by the fuel injection pumps.

The servo-motor located in the vertical bore of the governor housing, comprises differential (stepped) piston 44 (Fig.54d), sleeve 42 and round nut 41; to evacuate escape of air from the cavity under the piston, the piston has a drilled passage with special nut 43. Connecting rod 40 hinges the servo-motor piston to lever 39 secured rigidly on servo-motor longitudinal shaft 19.

The shaft splined end extended to the governor rear wall is designed to connect the leverage to the fuel injection pump control shafts.

Servo-motor shaft 19 carries also some members of the rigid and isochrome feedbacks. Isochrome pin 18 (Figs 54g, 54c) and sector 60 (Fig.54g) are hinged by means of a shackle to feedback connecting rod 59 provided with a cam lobe. The sector has a toothed rim to drive the load indicator and limiter.

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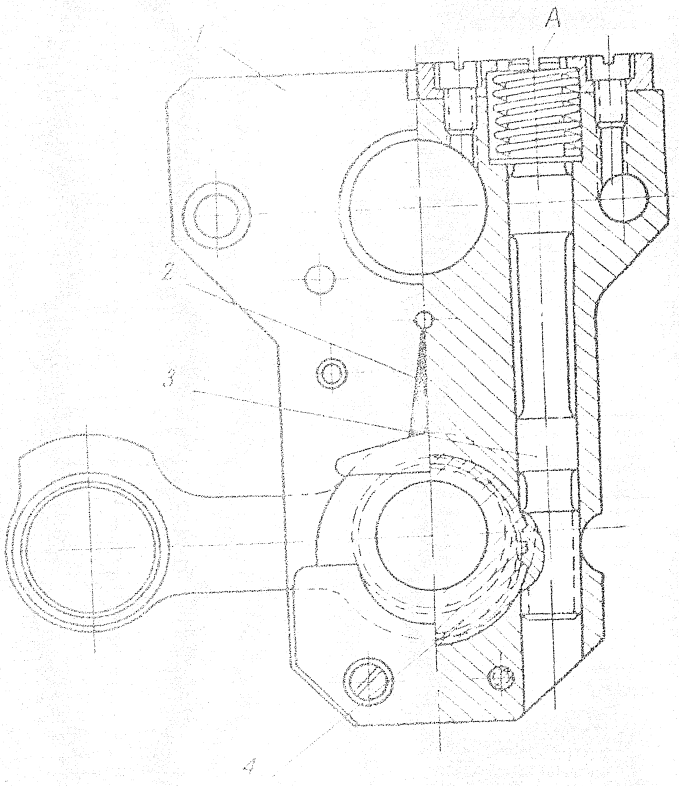

FIG. 59. IRREGULARITY RATE CHANGING MECHANISM

1 — bracket; 2 — irregularity indicator pointer; 3 — worm; 4 — cam; A — worm splined end

servo-motor piston to the upper end face of the speed-change sensor spring in such a way that loosening of spring 3 (Fig.57) and, consequently, reduction of speed correspond to the servo-motor piston travel towards the increase of load. The kinematic diagram of the rigid feedback is shown in Fig.60, in which the solid lines indicate the position of the mechanism during idle running, while the dotted lines deter-

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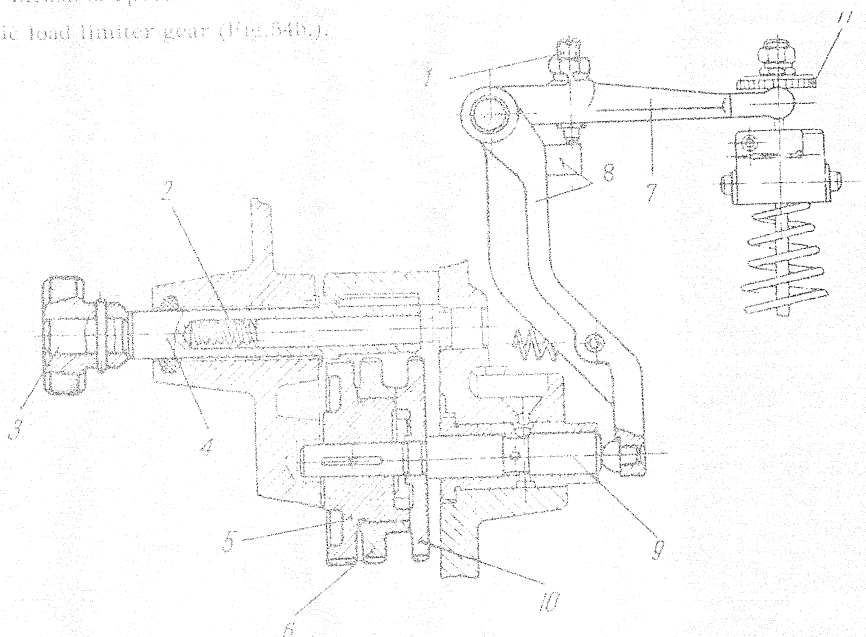

FIG. 63. LOAD LIMITER MECHANISM

1 – adjusting screw; 2 – spring; 3 – handle head; 4 – rod; 5 – gear; 6 – gear; 7 – lever; 8 – lever; 9 – toggle; 10 – gear; 11 – thrust plate of speed-change sensor slide valve

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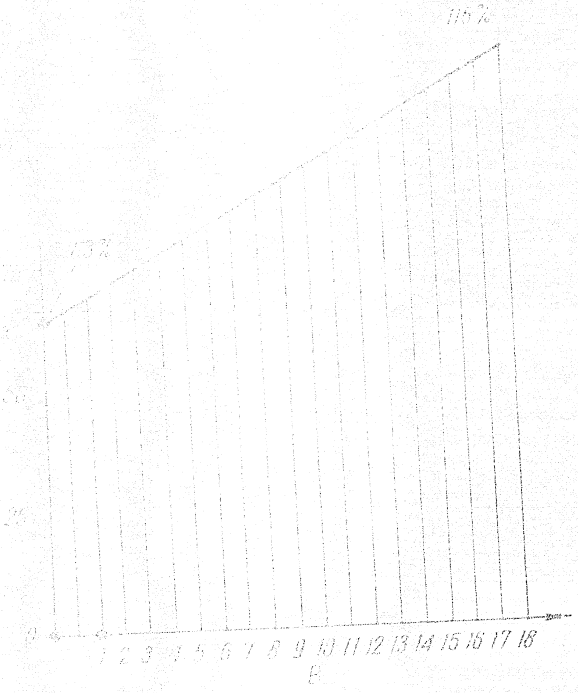

FIG. 44 AUTOMATIC LOAD LIMITING CHART

A — ultimate load, per cent (position of automatic load limiter indicator)
B — speed control handle position on scale

Governor base 34 accommodates drive shaft 35 with its oil seal 36, the lower supports of accumulator springs 54, return valves 55 of the oil pump, and oil drain plug 8 (Figs 54c, 54d, 54e).

Encased inside the housing are: governor main hydraulic passages, servo-motor, speed-change sensor, accumulator pistons, intermediate drive, and members of isodromic feedback. The housing face side carries a plexiglas oil level indicator (Fig.54a) communicating with the governor oil drain cavity.

Box 20 houses the following units (Fig.54c): speed-control mechanism, servo-motor shafts, manual and automatic load limiters, mechanism for changing the rate of irregularity, and central gear train.

Governor Operation

A. Speed adjustment. Should the diesel engine operate without governor, then, with the fuel injection pump fuel feed controls secured, the controlled speed of the engine would have been subject to considerable changes during the change of load.

To maintain the speed within the required ranges during any change of load, it is necessary that the amount of fuel injected by the fuel injection pumps be changed in accordance with the change of load, i.e. it should decrease during reduction of load and increase when the load gets higher.

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The necessary shifts of the fuel injection pump fuel feed controls are ensured automatically by the governor.

As already explained above, the centrifugal force of the speed-change sensor weights during steady rating gets equalized by the force of the spring. The position of governor parts during steady rating is seen in Fig.65. Here are the details of governor operation after the external load is reduced. In this case, the engine accelerates its speed (due to excess power generated hereon), the speed-change sensor weights actuated by the growing centrifugal force overcome the spring force, recede from each other and move the slide valve upwards. The delivery pipeline communicates with the servo-motor working cavity via the slide valve groove and the control passage, the servo-motor piston moves upwards, turns the servo-motor shaft, and the latter shifts the fuel injection pump feed controls by means of the intermediate leverage towards the decrease of fuel feed, i.e. to restore the equilibrium. Equilibrium will be obtained as soon as the new value of feed and, consequently, the value of power developed by the diesel engine comes into correspondence with the reduced load.

At the same time, the travel of the servo-motor piston is transmitted by the rigid feedback to the upper end face of the speed-change sensor spring.

In Fig.65 the direction of travel of the mechanism members, corresponding to the servo-motor piston travel towards the decrease of fuel feed, is indicated by arrows. In this case, the speed-change sensor slide valve is actuated by the spring to restore the equilibrium. As soon as equilibrium is restored, the spring appears to be compressed additionally, in compliance with the new position of the servo-motor piston. Hence, during reduction of load, the controlled speed somewhat increases, which is just necessary for ensuring the required degree of irregularity.

During the upward stroke of the servo-motor piston, the isodrome piston carried by the pin secured on the servo-motor longitudinal shaft moves upwards and creates a vacuum in the isodrome passage due to which the corrector slide valve moves to the right (Fig.61), and the corrector spring gets compressed. The maximum value of vacuum in the isodrome passage is determined by the corrector spring compressive force, which corresponds to the value of closing of by-pass hole B (Fig.61) by the corrector slide valve collar.

At small deviations of the slide valve (within its closing and its stroke up to the opening of the by-pass hole), the value of rarefaction rises along with the travel of the slide valve. The obtained vacuum acts upon the lower end face of the speed-change sensor slide valve and gets it ready for restoration of equilibrium, thus contributing to the promptness of the adjustment procedure.

Due to rarefaction, oil is sucked from the governor drain cavity into the isodrome passage through a small hole adjusted by isodrome needle 2 (Fig.61). As a result of oil flow, the isodrome piston gradually relieved of pressure, and the power effect of the spring 3 upon the speed-change sensor slide valve decreases. The constancy of the isodrome passage filling is ensured by the rigid one. All the above corresponding to the servo-motor piston travel towards the decrease of fuel feed restores the equilibrium, but does not ensure stability of operation. Stability of operation of the feedback depends only on the position of the weight centre of gravity relative to the axis of rotation and depends both on the servo-motor piston travel and its speed.

In order that the servo-motor piston should not overrun the position corresponding to the speed-change sensor equilibrium, the piston speed should decrease in time. This is ensured by the rigid feedback. Namely, as soon as the servo-motor piston moves

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this is just the reason why the rigid feedback is used to ensure the necessary rate of irregularity, while the isodromic feedback serves only for ensuring proper stability, and does not at all influence the remaining rate of irregularity.

Given below is a brief description of governor operation after the load increases.

The direction of travel of the governor members in this case is seen in Fig.66. The speed-change sensor weights approach each other; the slide valve lowers down and connects the servo-motor lower cavity with the drain line; the servo-motor piston moves downwards; the fuel feed controls get shifted towards the increase of fuel feed, i.e. to restore the equilibrium. Due to the rigid feedback, the speed-change sensor spring gets slightly released, and the now controlled speed lowers down. The isodrome piston moves downwards and produces a pressure in the isodrome cavity; the accelerator slide valve overcomes the spring force and moves to the left, but not further than it is determined by the value of its closing. The pressure formed herein actuates the speed-change sensor slide valve upwards to restore its equilibrium.

B. Load limiting. If the servo-motor piston moving in the direction of fuel feed occupies a position in which the value of feed and, consequently, the load which may be carried by the diesel engine is equal to the smallest value set by one of the two load limiters (manual or automatic), then, as described above, the load limiter operates. The speed-change sensor slide valve lifted by the forked lever connects the servo-motor controlled cavity with the delivery pipe line. This will stop further downward travel of the servo-motor piston (towards the fuel feed).

C. Engine stopping. If the speed-adjusting mechanism is set in position STOP, the speed-change sensor coupling lifts the thrust plate of the speed-change sensor slide valve by means of the load limiter forked lever. The servo-motor lower controlled cavity starts communicating with the delivery pipeline via the slide valve, and the servo-motor moves quickly right home, shuts off the fuel feed and thus stops the diesel engine.

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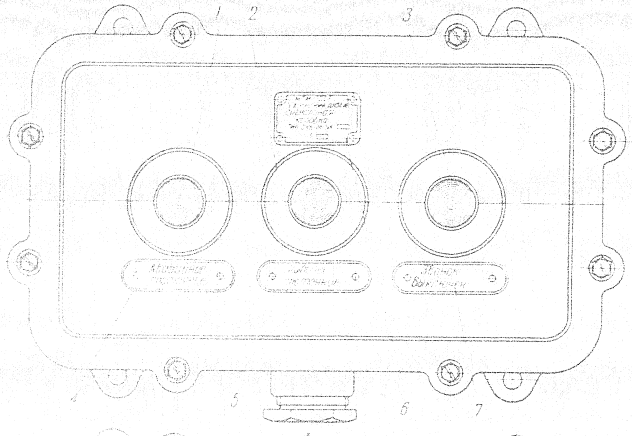

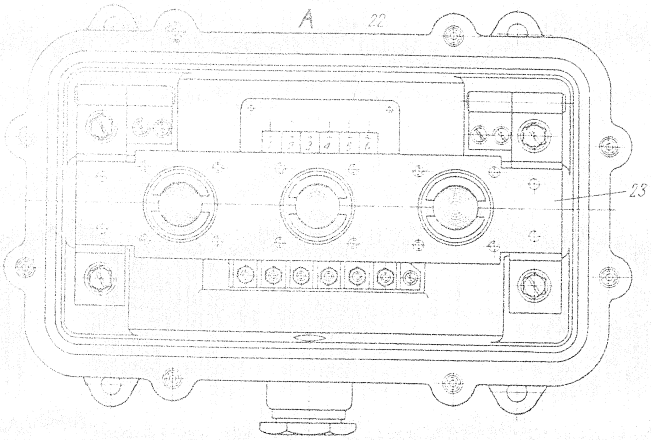

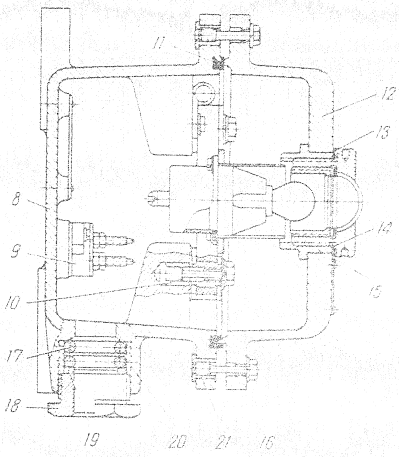

FIG. 76. SIGNAL BOX

1, 2, 3 – tell-tale lamps; 4 – name plate EMERGENCY STATE (АВАРИЙНОЕ СОСТОЯНИЕ); 5 – name plate WORKING POSITION (РАБОЧЕЕ СОСТОЯНИЕ); 6 – trade mark; 7 – name plate BELL OFF (ЗВОНОК ВЫКЛЮЧЕН); 8 – housing; 9 – terminal board; 10 – bushing; 11 – gasket; 12 – cover; 13 – washer; 14 – gasket; 15 – bushing; 16 – screw; 17 – rubber ring; 18 – gland nut; 19 – pressure washer; 20 – blank plug; 21 – bushing; 22 – wiring table; 23 – plate for fastening the lamp fittings; A – view with cover removed

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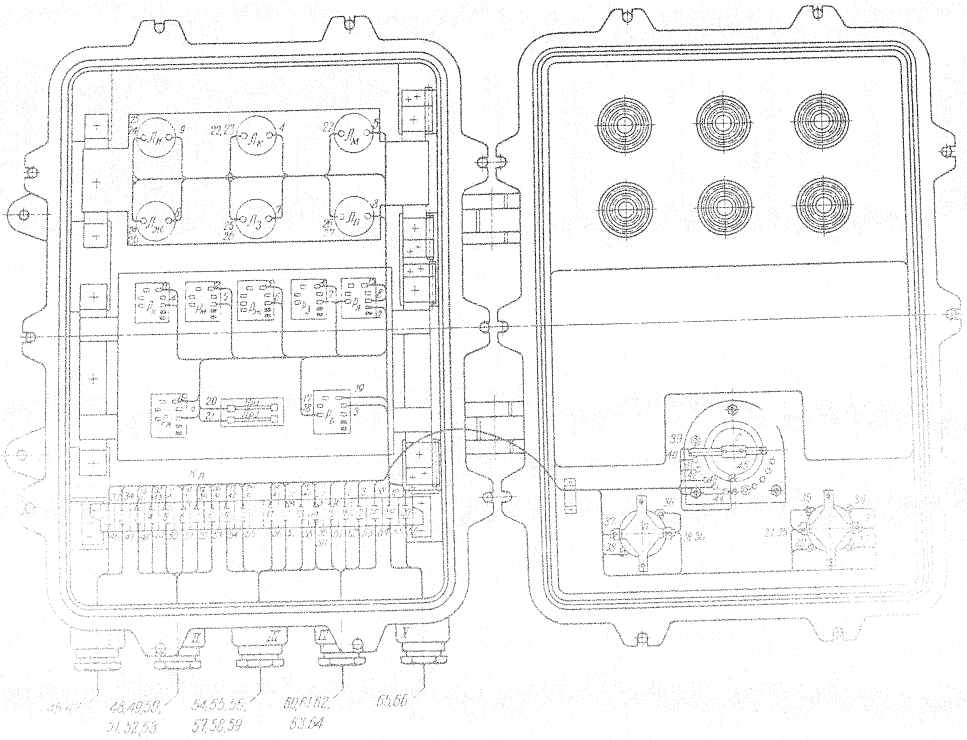
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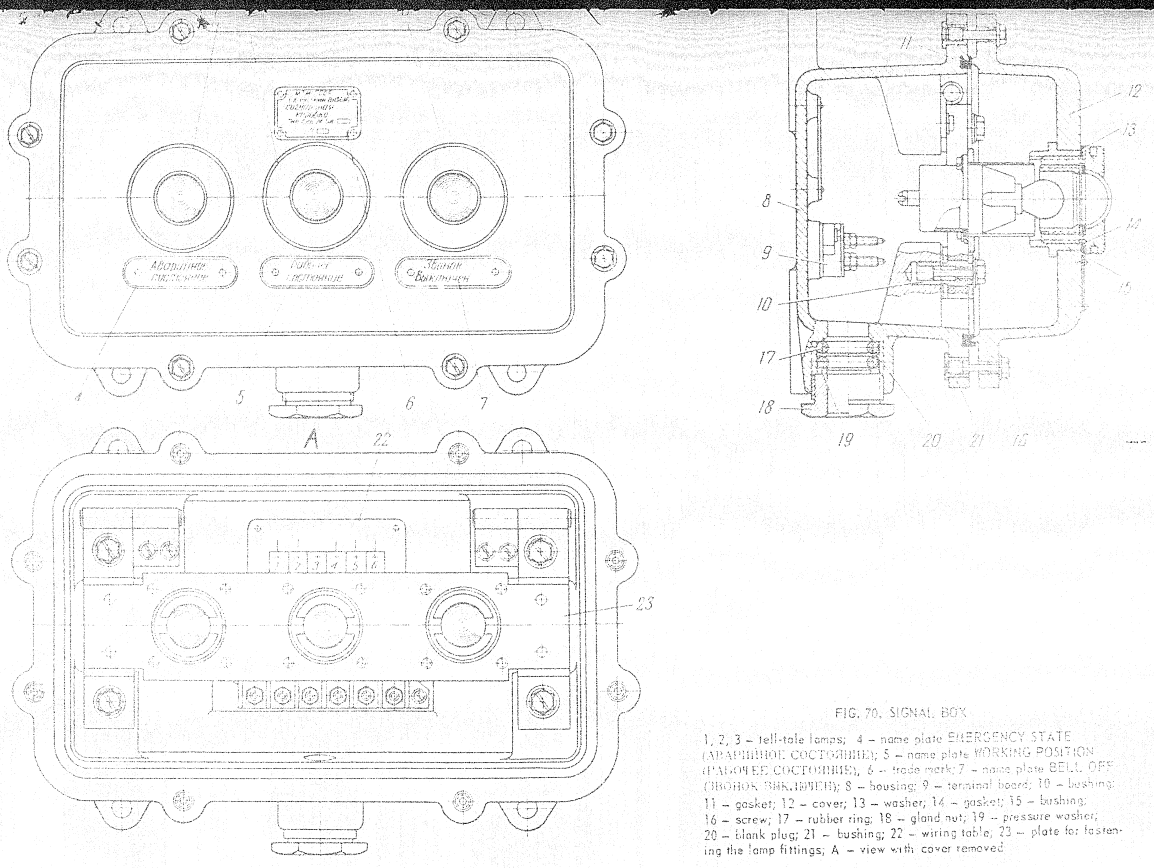

FIG. 70. SIGNAL BOX

1, 2, 3 – tell-tale lamps; 4 – name plate EMERGENCY STATE (АВАРИЙНОЕ СОСТОЯНИЕ); 5 – name plate WORKING POSITION (РАБОЧЕЕ СОСТОЯНИЕ); 6 – trade mark; 7 – name plate BELL OFF (ЗВОНОК ВЫКЛЮЧЕН); 8 – housing; 9 – terminal board; 10 – bushing; 11 – gasket; 12 – cover; 13 – washer; 14 – gasket; 15 – bushing; 16 – screw; 17 – rubber ring; 18 – gland nut; 19 – pressure washer; 20 – blank plug; 21 – bushing; 22 – wiring table; 23 – plate for fastening the lamp fittings; A – view with cover removed

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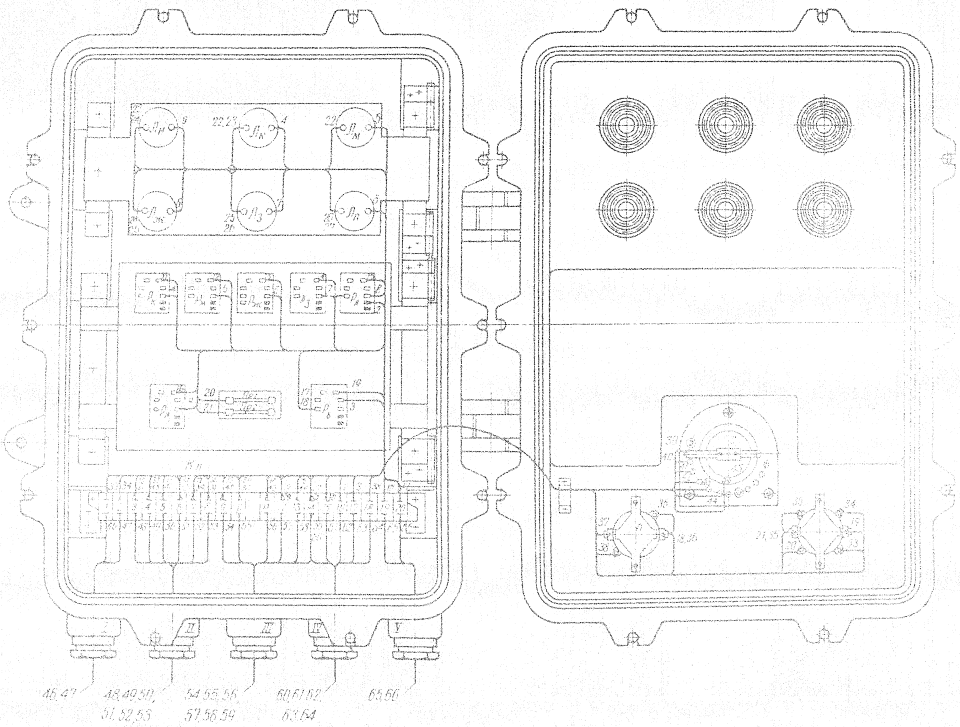

FIG. 71, SIGNAL PANEL WIRING DIAGRAM

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The setting part of the diagram includes the sensors which convert some operation parameter (temperature, pressure) into closing of electric circuit contacts.

The signal panel, signal box and the bell-and-howler pertain to the operating part of the diagram.

When sending a signal indicating that the diesel engine cooling water is overheated, the circuit functions as follows (when sending other signals, the circuit operates in a similar manner):

As soon as the panel is cut in by packet-type switch B (Fig.67), blocking relay P_{36} operates, closes its contacts and prepares the individual-point relay circuits for receiving the signals. Assume that cooling water overheating sensor 4 operates and closes its contact. This closes the circuit of the P_{36} individual-point relay winding, and the relay operates as well. Then the relay normally closed contact opens and breaks the circuit of green lamp $Л_{36}$ on the signal box. The normally open contacts close and make the circuit of red lamp $Л_{36}$ on the signal box and the circuit of tell-tale lamp $Л_{36}$ mounted on the panel.

Inscriptions interpreting the sent signal are made on frame plates available under the caps of each tell-tale lamp. For example, the name plate under lamp $Л_{36}$ bears an inscription WATER OVERHEATED (ПЕРЕГРЕВ ВОДЫ) see Fig.60.

The circuit diagram ensures duplication of the light signal by a sound one. The bell and howler gets energized as soon as the red and the tell-tale lamps come up.

Switch П allows to cut out the bell when it is necessary to eliminate a fault.

As soon as white lamp $Л_{38}$ located in the signal box comes up (see Fig.70), it means that the bell is deenergized. The cable diagram of the signalling system is shown in Fig.68.

Primary Instruments (Sensors)

The description of the primary instruments (sensors) has been given in "Instructions on Mounting and Maintenance of Models KP-1 and KP-2 Combination Relays" applied to each instrument.

Secondary Instruments

Signal Panel

The entire operating part of the signalling system is based on model PO18-20 relays which convert the impulses sent by the primary sensors into light and sound signals of the secondary instruments.

Closing of the sensor contacts causes operation of the panel individual-point relay (each sensor actuates one respective relay).

The individual-point relay contacts close the circuits of the red lamp, the bell and the preceding board.

The panel comprises: relay frame 41 (Fig.69) with seven electromagnetic relays (type PO18-20, see 4), signalling members, packet-type change-over switch B 47 to cut the panel in and out, packet-type change-over switch 40 for energizing and deenergizing the bell, twelve-position change-over switch 48, mounting with terminals, name plates 39, 38, 36, 35, sealing and connecting parts, body 43, and cover.

Twelve-position change-over switch 48 is a [illegible] and [illegible] serves to check the [illegible] and serviceability of the lamps.

The switch set in one of the operating positions [illegible] one of the [illegible] to the [illegible] one of the extreme operative positions [illegible] the bell [illegible] the [illegible] the [illegible] operation. This allows to [illegible] the [illegible] the [illegible] the

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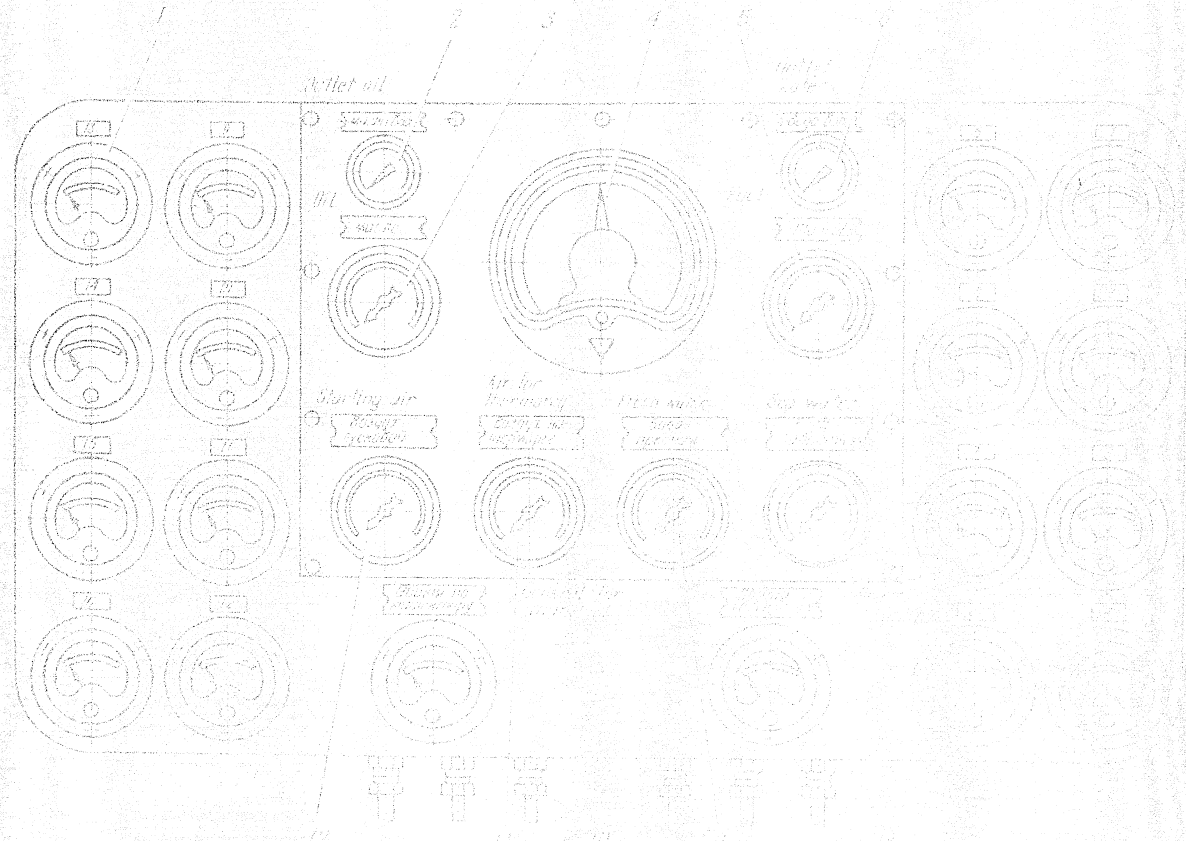
Chapter XII

MEASURING INSTRUMENTS

The diesel engine measuring instruments are located on the instrument board (fig. 1) on the control panel.



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(b) electric tachometer indicator showing the diesel engine speed;

(c) pressure gages for indicating the pressure of oil, fuel, fresh and sea water, and starting air intended for thermoregulation;

(d) manometric distance thermometers measuring the diesel engine water and oil outlet temperature.

Mounted on the remote control panel (Fig. 40a) are the following instruments:

(a) electric tachometer indicator;

(b) millivoltmeters for measuring the temperature of exhaust gases in the manifolds of each row of cylinders;

(c) pressure gauges to indicate the pressure of oil, fresh and sea water, and starting air.

The diesel engine mounts also a summating revolution counter (see Fig. 14a). A maximum pressure indicator rated for a pressure of 160 kgf/cm^2 ensures periodic measurement of pressure in the working cylinders, while two mercury thermometers enclosed in casings allow to check the temperature.

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Chapter XIII

SHAFT BARRING ARRANGEMENT

The shaft barring arrangement is intended to turn the crankshafts.

It represents a five-stage reduction gear with a total ratio equal to 14,400.

The first stage is a V-belt transmission which connects pulley 5 on the shaft of electric motor 7 with pulley 10 on reduction gear 4.

The second stage is a gearing, and the third one is a worm drive; their gears are enclosed in the reduction gear housing. Bevel gearing consisting of gears 9 and 11 make up the fourth stage. The last fifth stage represents worm 2 and a worm gear fitted on the flange of the power take-off shaft. Worm 2 runs in antifriction bearings mounted in the supports of plate 12 which also carries the reduction gear housing. Plate 12 is suspended from the axle of bracket A and is secured by a nut. The plate is free to rotate about the axle, due to which worm 2 can be engaged with, or disengaged from the worm gear fitted on the power take-off flange. Engaging mechanism 15 is used to engage or disengage the shaft barring arrangement.

Lock 1 inserted into the hole of stop 13 and the main drive housing wall secures the lower end of plate 12 in positions for engaging or disengaging the shaft barring arrangement.

The shaft barring arrangement is driven by electric motor 7. The motor is installed on frame 14 which can be dropped off by the force of two springs (not shown in the drawing), this ensuring tension of belts 6 when in disengaged position. The V-belt transmission and the worm are enclosed in detachable casings.

With the shaft barring arrangement engaged, the diesel engine cannot be started, since the rod of interlocking slide valve does not admit starting air to the main starting valves.

The housing of reduction gear 4 is primed with summer grade automobile transmission oil, GOST 542-50, up to the level indicated by oil level indicator 3.

The bearings of worm 2 are lubricated with [illegible] GOST 1631-61.

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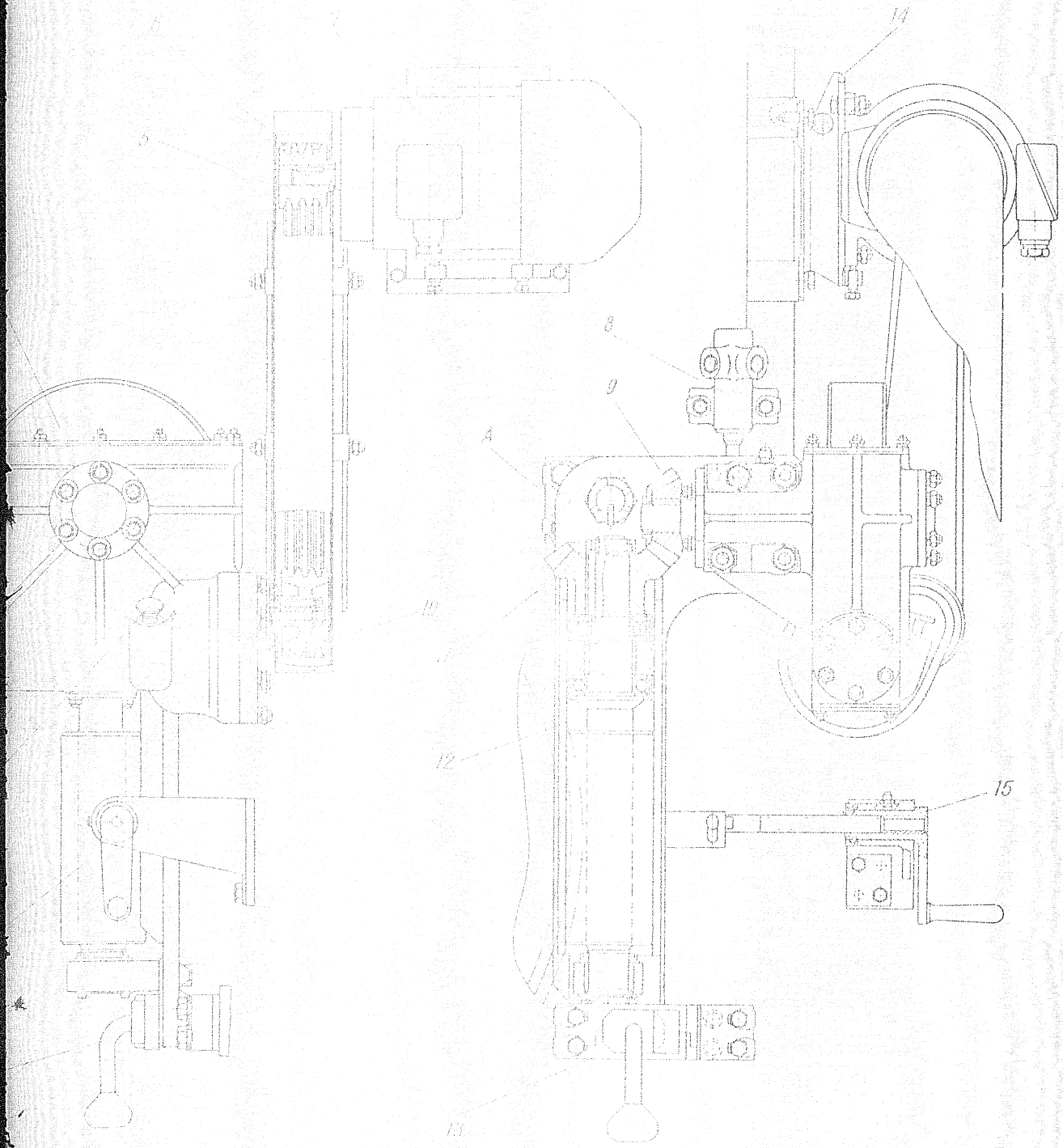

FIG. 2. SIDE BARRIER ARRANGEMENT

2 – worm; 3 – oil indicator; 4 – reflection gear; 5 – pulley; 6 – [illegible]; 7 – electric motor; 8 – [illegible] unit; 9 – gear; 10 – pulley; 11 – gear; 12 – plate; 13 – stop; 14 – frame; 15 – [illegible]

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Part II

OPERATING AND MAINTENANCE INSTRUCTIONS

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Chapter II

OPERATING THE ENGINE

PREPARING THE DIESEL ENGINE FOR STARTING

A. Preparing the Diesel Engine for Starting After Repairs or Overhaul or Long Stoppage (But at Least Once a Month)

1. Inspect the diesel engine and its accessories to see if there are any foreign objects on them.

2. Make sure that:

(a) the handles of the emergency control station and the central control panel, as well as the speed control handle on the governor, are in position STOP;

(b) the governor manual load limiter indicator is in a position indicating 105 to 110 per cent on the load scale;

(c) the control selector switch handle is set to CONTROL STATION;

(d) the air pipeline valves are closed, and shut-off valves 7 (6a, 9a) are open.

3. Engage the shaft barring arrangement worm with the power take-off shaft rim and lock it in this position.

4. Pull the handwheel manually to check free travel of all the safety inspection covers on the upper covering, lower crankcase, main drive, and on the drive for major accessories.

5. Check condition of the joints and fastening of diesel engine auxiliary systems and motor. Make sure that all cocks, valves and flaps are in positions specified in the ship's instructions.

6. Bleed air out of the upper points of diesel engine cooling system, and fill the system with fresh water. Cut in the water heater, and heat the water in the cooling system to a temperature of at least 40°C above zero by forcing it through the system with the aid of the pump of the independent pump. After warming [illegible]

7. Pressure test the engine [illegible] by means of the independent pump.

When pressure testing, check the [illegible]

(a) sealing of [illegible] valve [illegible] sleeves (with its [illegible]

(b) sealing of [illegible]

8. Operate the [illegible]

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9. Make sure that the oil and fuel pipes are not leaking. Screw out the filter drain plug and check the oil and fuel for admixture of water.

10. Check absence of water in the oil by taking samples from the lower part of the tank and cooler.

11. Check:

(a) amount of oil in the circulating tank, which should be at least 2/3 of the tank capacity;

(b) level of water in the expansion tank, the level must be within 2/3 of the tank height;

(c) amount of fuel in the service tank;

(d) pressure of air in the starting cylinders. Scavenge the cylinders of condensate.

12. Check level of oil in the speed governor. If necessary, clean oil filler plug and screen, and then add oil into the governor up to the centre mark available on the oil level gage glass.

13. Cut in the oil heater and heat the oil in the circulating tank up to a temperature of at least 30°C above zero by forcing out through the oil heater with the aid of the independent pumps. When heating, take care to see that the oil pressure downstream of the pump is not in excess of 7 kgf/cm^2 (0.7 MPa) to be adjusted by returning part of oil into the tank via oil pressure adjusting valve(s).

14. Having warmed the oil in the tank, engage the scavenging and priming independent pumps, prime the diesel engine with oil, and at the same time turn the crankshafts by means of the shaft barring arrangement.

15. Check the supply of oil to the diesel engine by the readings of pressure gauge (Fig. 42.6(3)-5) on the engine instrument board.

16. Scavenging of oil from the diesel engine sump is to be checked by the readings of the pressure gauge. At the scavenging pump outlet the pressure should be at least 0.2 kgf/cm^2 (0.02 MPa).

17. When priming the oil and cranking the diesel engine, check through the handholes supply of oil to all the main, crankpin and coil bearings, and to the main drive and the drives for major and minor engine valves; check flow of oil out of the piston cooling pipes, and check also proper sealing of the joints of oil pipelines in the engine crankcases.

Notes: 1. During the entire period spent on preparing the diesel engine for starting, prime the engine periodically with oil, and maintain hereon the engine oil outlet temperature within at least 30°C above zero. Do not prime the engine with oil for a period exceeding 10 minutes.

2. In all cases when turning the diesel engine by means of the shaft barring arrangement, keep the indicator valves open.

18. Cut out both independent pumps and change over the valves for the supply of oil to the cooler and filter on the scavenging line of the system. Engage the independent scavenging pump, prime the filter and cooler with heated oil from the circulating tank, and the temperature of oil downstream of the cooler is at least 30°C above zero, determine its pressure and change over the pipeline valves for scavenging oil from the engine sump. Cut out the shaft barring arrangement. Disengage it from the power take-off clutch and secure it in this position.

Note: Warming of the cooler and filter may be done also by priming the diesel engine in accordance with Para. 14, by scavenging the oil from the sump or sump and by circulating through the filter and cooler.

19. Make sure that the receiver and exhaust manifolds are free of oil, drain the oil from the receiver oil drain pipes and exhaust manifolds are open, and that the pipes are tightly fixed in the pipes, if necessary.

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SERVICING THE DIESEL ENGINE DURING OPERATION

64. To reduce wear of the engine parts during daily service, proceed to bring the diesel engine to full power running gradually as follows:

slow speed – for at least 3 minutes;

half speed – for at least 5 minutes;

full speed – for at least 5 minutes.

The change-over from one rating to another should be made gradually in the course of at least two minutes.

When starting and warming up the diesel engine in the starboard shaft, see that the blades of the variable-pitch propeller (VPP) are in a position corresponding to the position of the pointers of the starboard pitch indicator (SPI) at 0 mark.

Note. If the engine running at ratings not lower than the half speed has been stopped for a short period of time (up to 15 min), and the temperature of water and oil in the diesel engine and its systems has not dropped down lower than 40°C above zero during the standstill period, the started engine may be then brought to full power gradually in the course of 3 minutes.

65. In emergency cases, the diesel engine prepared for starting in accordance with Sub-Section "Preparing the Diesel Engine for Starting During Daily Operation" should be warmed up at slow speed rating for three minutes, then at half speed rating until the engine oil and water outlet temperature is 40°C above zero. Now the engine may be brought to full power with gradual increase of speed in the course of three minutes.

Note. The time passing from the moment of starting up to the development of full power in emergency cases is roughly 10 minutes.

66. Do not run the engine idle for more than 30 minutes, and do not run it at dead slow for longer than 1 hour.

Note. If a longer period of slow speed operation is required, run the engine for 10 to 15 minutes at full speed after each hour of its slow speed operation so as to prevent formation of carbon in the gas exhaust flow path.

67. During diesel engine operation, watch readings of measuring instruments, inspect the engine and its systems and listen to the engine every hour of its operation. When operating the diesel engine from the remote control panel, ensure stable operation of the air reducers, so as to maintain the given speed (with the engine controls being unchanged).

68. Change over the engine from one rating to the other gradually, without abrupt change of speed.

69. As soon as the engine develops the required rating, write down its speed in the Log Book. Thirty minutes after the rating has been attained, and then every 4 hours of operation (in case the engine operates continuously at this steady rating), make the following records in the Log Book:

(a) diesel engine speed;

(b) position of governor load indicator pointer;

(c) temperature of exhaust gases in cylinders and readings of pyrometer;

(d) engine oil outlet temperature;

(e) engine fresh water outlet temperature;

(f) engine oil inlet pressure.

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(g) engine fresh water inlet pressure;

(h) fuel pressure;

(i) pressure of sea water downstream of pump;

(j) level of oil in circulating tank.

70. At least once a watch do the following:

(a) scavenge the thermoregulator air filters;

(b) lubricate the air distributors with solid oil by turning the lubricator cover through a complete revolution;

(c) check (to the touch) the temperature of the pipes supplying air to the starting valves and of the high-pressure pipes running to the injectors. The temperature of the pipes should not exceed 50°C. Heating of the starting valve air feed pipe indicates that the valve is leaking. Overheating of the high-pressure pipe due to high intensity of hydraulic shocks is caused by the injector nozzles are choked.

71. During engine operation under ordinary conditions, follow the working parameters specified in the engine Service Log.

When operating the engine at low temperatures and reduced exhaust backpressure, bear in mind that the exhaust gas temperature and fuel consumption values will differ considerably from the values given in the Service Log.

In this case, remember that each time when suction temperature drops by 10°C the following will take place:

(a) the hourly fuel consumption at rated speed will reduce by 9 kg/hr;

(b) the exhaust gas temperature will drop down by 15 to 20°C.

On objects where the backpressure at diesel engine exhaust line is lowered down to 30 - 40 mm Hg, as compared to the value specified in the engine Service Log (100 mm Hg):

(a) the fuel consumption will reduce by 16 to 17 kg/hr;

(b) the exhaust gas temperature will drop down by 20°C.

72. During diesel engine operation under extremely unfavourable conditions (navigation in heavy weather, suction temperature above 25°C, or operation of one diesel engine in double-shaft installations), when running at flank speed, lower down the engine r.p.m., or reduce the turn of the blades of the variable-pitch propeller.

In this case, during engine operation at reduced speed (within a range of 500 to 540 r.p.m.), take measures to prevent increase of exhaust temperature above the value ensured by this particular engine during rated speed so as to keep within the service ratings of the diesel engine.

73. When the engine is running at rated speed under extremely unfavourable conditions, follow the basic ultimate parameters indicated below.

Note. Diesel engine operation at outer performance drop of engine speed caused by catching the maximum fuel feed stop) is not allowed.

BASIC ULTIMATE PARAMETERS OF DIESEL ENGINE OPERATION AT RATED POWER AND SPEED

1. Combustion pressure in cylinders, kg/cm²
2. Difference in combustion pressures between cylinders, kg/cm²
3. Fuel pressure after filter (2nd ф-я) ..... kg/cm²
   Fuel pressure drop in filters (2nd ф-я) ..... not more than ..... kg/cm²

   Note. Should pressure drop increase above ..... kg/cm², clean the filters.

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Temperature of exhaust gases in cylinders, °C ..... up to 480

Difference in exhaust gas temperatures between cylinders, °C ..... up to 100

Temperature of exhaust gases in starboard and portside manifolds upstream of turbine), °C ..... up to 500

Engine oil outlet temperature, °C ..... 70 to 75

Engine fresh water outlet temperature, °C ..... 65 to 70

Engine oil inlet pressure, kgf/cm^2 ..... at least 4

Engine fresh water inlet pressure, kgf/cm^2 ..... at least 1.0

Pressure of sea water downstream pump, kgf/cm^2 ..... at least 1.0

Rarefaction in crankcase, mm of water ..... 50 to 60

Maximum overspeed at no load, r.p.m. ..... up to 100

74. During engine operation at minimum speed, observe the following limits pertaining to:

Deviation of speed from a minimum up to high, degree ..... 2°

Engine oil inlet pressure, kgf/cm^2 ..... 1.5

Engine fresh water inlet pressure, kgf/cm^2 ..... at least 0.3

Pressure of sea water downstream of pump, kgf/cm^2 ..... at least 0.3

Deviation of speed at idle running, r.p.m. ..... up to ±50

75. During turning of the ship heavy rating, the temperature of exhaust gases in manifolds (upstream of the turbine) may rise by 40° as compared to the gas temperature obtained during the engine steady operation rating before turning began.

Besides, when the ship is being turned at diesel engine rated speed, the following should be observed:

(a) the temperature of exhaust gases in manifolds should not exceed 500°C;

(b) the drop of crankshaft speed (diesel engine operation at outer performance caused by the controls set to the maximum fuel stop) should not exceed 50 r.p.m.

In case the temperature of exhaust gases exceeds the above value, reduce the load by lowering down the speed. Do not run the engine at outer performance ratings (during turning of the ship) longer than 10 min.

CAUTION. On ships where the turning procedure usually causes overloading of engines above the values indicated in Part 75, reduce the engine speed down to 800 r.p.m. before turning the ship.

76. Ensure continuous separation of oil during diesel engine operation. The separator oil inlet temperature should not be lower than 85°C.

Note. During engine operation at slow speed, oil is fed to the separator through the cooler.

77. When the engine operates, take care to engage both sections of the oil filters on the suction and delivery lines of the lubricating system. Never disjoint the filtering cartridges of the delivery line oil filters during operation of the diesel engine.

78. Every 100 hours of operation, carry out complete measurement of diesel engine service parameters, with the engine running at rated speed.

When measuring:

(a) attach periodic control instruments to the test points;

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Cause	
7. With governor speed control handle set ... rated speed, the temperature of exhaust gases ...	
(a) sections of transmission from speed governor to fuel injection pump racks disengaged;	
(b) rack of one or several fuel injection pumps jammed;	
(c) maximum fuel feed stop set wrongly.	
8. White, vapour-like exhaust of diesel engine	
(a) water gets into exhaust manifolds;	(a) pressure-test the diesel engine with water, find and eliminate the cause of entrance of water into manifolds.
(b) air cooler leaky.	(b) Stop the diesel engine, before stopping the engine, open the cocks on the receiver drain pipes. Disconnect the faulty cooler and pump out the oil from the sump and the tank for fuel oil. Check the oil filters and fuel service tank for absence of water. Check operation of the cylinder and piston group of the engine, wash the engine with fuel oil and prepare it for starting.
9. Temperature of fresh water and oil ...	
(a) sea water pump delivery insufficient, water pressure downstream of pump below normal;	
(b) sea water cavities in water and oil coolers clogged. Pressure of sea water downstream of pump above normal.	

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Cause	
12. Deviation of water pressure in the expansion tank take place during diesel engine operation ing	
(a) air gets into cooling system;	
(b) gas escapes from working cylinders into cooling cavities through gaskets on injector and starting valve pipe unions, or through rubber sealing rings of cylinder sleeves in exhaust manifold sections.	
13. Slow lowering or gradual rising of water level in expansion tank during diesel engine operation	
Water leaks through water cooler pipes or along tube plate periphery (through soldered joints).	Repair the cooler at the first opportunity.
14. Deviation of diesel engine oil inlet pressure and frothing of oil in circulating tank during engine operation	
Reducing valve by-passes too much oil from delivery cavity into suction cavity of oil pump delivery section due to insufficient tension of valve spring. Valve vibrates during engine operation, and opens at a pressure below normal; pump capacity gets reduced. Acceleration of diesel engine speed causes no increase of oil pressure downstream of pump.	Tighten up the reducing valve spring during pump operation.
15. Increased oil consumption, accompanied by smoky gas exhaust (blue smoke) and by throwing oil in the form of drops through the exhaust manifold	
(a) incorrect mounting of oil-control rings on one or several pistons;	

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Cause	
(d) jamming of servo-motor in governor	
18. Temperature of exhaust gases in one of the cylinders rises	
(a) fuel injection advance angle disadjusted;	
(b) injectors faulty or disadjusted.	
19. Too high exhaust gas temperature in cylinders of one row	
(a) constant pressure valve on the fuel pipeline of the other row of cylinders stickly;	
(b) exhaust pipeline screen clogged;	
(c) fuel injection advance angle in one cylinder row disadjusted.	

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Chapter V

DISASSEMBLY, INSPECTION, REPLACEMENT AND ASSEMBLY OF DIESEL ENGINE PARTS AND UNITS

GENERAL

1. Do not disassemble properly functioning units or mechanisms unless necessary.

2. Before starting the disassembly procedures prepare the necessary hoisting means in accordance with the weights of the units to be disassembled; select and prepare the required tools and appliances (the sketches of tools and appliances are presented in Appendix 18). See that the tools and appliances delivered with the diesel engine are used in compliance with their direct purpose, and never use worn or damaged tools.

3. Prior to disassembling the outer joints, wash the diesel engine thoroughly until dirt is completely removed, then wipe the outer surfaces of the unit to be disassembled, as well as the adjacent surfaces, with clean cotton cloth until dry.

4. When disassembling, take measures to prevent entrance of dirt and foreign matter into the inner cavities of the diesel engine and of the units disassembled. After the units or parts are removed, inspect their attachment places and close the latter with blind veneer, paronite or cardboard spacings. Wrap the flanges and unions of the disconnected pipes of the engine fuel, oil, air and water systems in dense oil-paper (parchment) and bind them over. As soon as a part or unit are detached, fit the removed fastenings into place or put them into a separate box.

5. Before disassembling the bearings, gearsand other movable joints, measure the clearances.

6. During the disassembly of units make sure that the marking (see Appendix 9) is intact, and pay attention to see that match marks are available on the mating parts (if no match marks are seen, make them anew). When assembling the units pay attention to the location of the marking or match marks, so as to mount the parts properly in their normal position.

7. Take measures to ensure safety of the removed parts and to protect them against damage. Wash all the removed parts with clean diesel fuel, wipe them dry by means of clean cloth, or blow them out with compressed air. Coat the part ground surfaces with a thin layer of clean oil used for lubricating the diesel engine. If the work is interrupted for some period, cover the parts with dense oil-paper (parchment) or with clean tarpaulin.

8. Screw the studs out of their places only in cases when the studs are to be replaced, or if the part into which the studs are screwed needs repairs or is to be changed.

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9. To disassemble interference fits, heat the parts by special rigs, if no special rigs have been assigned for this particular case, use oven or ventilation of warm air.

10. Right before assembling the mount parts (parts of the diesel engine, clean them of dirt, corrosion-preventive lubricant, wash them with benzine, dry and blow out with compressed air. Inspect all passages, lubricating and threaded holes thoroughly, and purge them with compressed air; lubricate the part friction surfaces with clean oil used for lubricating the diesel engine.

Remove burrs, nicks, fine scores, etc., by filing or scraping, with the corrected parts again.

11. During the assembly procedure lubricate all the threaded joints with clean oil used for lubricating the diesel engine; an exception to this is the bolts and studs and nuts that fasten crankshaft bearing, connecting rod blades and connecting rod bolts; these joints are to be lubricated with castor oil. Apply fine flaky graphite to the threaded joints subject to high temperatures.

The bolts and the nuts of the studs that fasten the part or part are to be tightened up gradually and uniformly; never tighten up the adjacent nuts completely one after the other.

12. Do not re-use the locking-tab washers, strips and cotter pins. Fit the cotter pins into the stud and bolt holes so that they are not loose and that they do not project above the nut slot.

13. Before installing the next part or unit, check tightening or locking of the nuts or bolts which fasten the parts or units already installed.

14. Carry out disassembly of fuel injection equipment, speed governor, valves and slide valves of the starting system, remote control panel and thermoregulator control units in specially assigned places, and use separate clean tanks with filtered diesel fuel for washing the precision couples and other parts.

To ensure more thorough removal of dirt from the precision couples, wash them successively in two tanks.

15. Disassemble and assemble the diesel engine, as well as its separate units and parts, in a closed room with a temperature not lower than 10°C above zero, and take measures against the parts and the disassembly sites against entrance of dust, dirt or water.

16. Enter the results of inspections and checks into the Log Book. All cases of replacement and measurement of parts must be entered into the diesel-engine Service Log.

17. In case the main propelling units and parts have been replaced, run-in the diesel engine in accordance with the directions given in Chapter VI.

MAIN BEARINGS

18. Take out the half-bushes of the main bearings of the upper and lower crankshafts (if the latter have not been removed) successively through every other bearing.

To take out the half-bushes of the lower crankshaft main bearings, proceed as follows:

(a) remove the bearing cap jack, for which purpose unscrew the locknut, unscrew it by means of wrench 47 B-232-035-1, then drive the screw into the jack body;

(b) detach the bearing cap together with the upper half-bush;

(c) move the lower half-bush out of the bearing mount bed. To this end, fit appliance 47 B-232-180 on the crankshaft main journal by inserting the appliance pin into the main journal hole, then turn the crankshaft and move the half-bush out of the mount. Turn herein the crankshaft in such a way that the half-bush lock comes out of the mount upwards.

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29. The main gear of clearances [illegible]

(a) oil clearances [illegible]

The difference in clearances [illegible] charger should not exceed 0.05 mm;

(b) a 0.03-mm thick feeler gauge [illegible] half-bush and the bed;

(c) the clearance under the [illegible] up to 0.03 mm;

(d) the side radial clearances of the [illegible] be as follows:

- 0.07 to 0.30 mm - for half-bushes located above the joint face;

- 0.05 to 0.25 mm - for half-bushes located below the joint face.

The difference between the largest and smallest side clearances for all the bearings on one side of the shaft, in each of the two horizontal planes (above and below the joint face) should herein not exceed 0.07 mm, while for one bearing the difference between respective clearances "bow" - "stern" must not be in excess of 0.03 mm.

30. See that the axial play of crankshafts in the thrust bearings is within the values indicated in the table of mounting and operation clearances.

31. After running-in of diesel engine is accomplished, repeat the checking of clearances in the bearings with replaced working half-bushes, and also in the adjacent bearings.

UPPER CRANKSHAFTS

32. To remove the upper crankshafts, proceed as follows:

(a) remove the diesel engine upper covering. To this end, disconnect the crankshaft ventilation pipe (together with the oil separator), undo the bolts which fasten the covering flanges, then remove the covering by means of the wire rope secured in its lugs;

(b) detach the control rods and remove the covers of camshaft drive planetary mechanism hand-holes. The overspeed governor operating mechanism must be set herein in its working position;

(c) check mutual location of diesel engine crankshafts and camshafts according to the match-marks.

To check mutual location of the crankshafts, arrange the first cylinder crank in the inner dead center, in compliance with the graduation available on the splined coupling of the gearbox lower crankshaft.

Take up backlash in the teeth of main drive gears by turning the [illegible] the shaft barring arrangement in the ASTERN direction. With the position of the [illegible] crankshaft, the match-marks made on the splined couplings of the upper crankshafts must be horizontal and should align with the upper surface of diesel engine frame.

Mutual location of the camshafts and crankshafts is to be checked as follows: [illegible] engine in direction ASTERN and set the cranks of the 1st and 14th cylinders alternately in the inner dead center, in compliance with the graduation available on the splined couplings of the lower crankshafts.

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(f) coat the thread of the [illegible] than to enable the main bearings

(g) insert the thrust bearing [illegible] surfaces when inserting the [illegible]

Check the thrust bearing [illegible] at a bracket; the indicator stand should [illegible] some position by means of screws [illegible]

(h) suspend the upper pistons, [illegible]

Grease appliance 47 [illegible] 252-051

to connect the crankshaft coupling to the main drive gear coupling by means of the intermediate shaft. Carry out mounting in accordance with the marks. Marks "O" made on the end faces of the splines of the intermediate shaft and main drive gear coupling must form a triangle at the meshing (Figs 76, 77);

(i) check mutual location of crankshafts and camshafts in compliance with the match-marks;

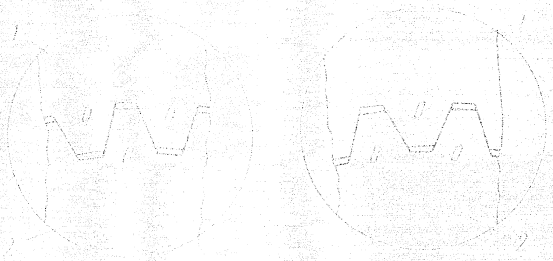

Fig. 76

1 – coupling, 2 – shaft

Fig. 77

1 – coupling, 2 – shaft

(j) check the compression chamber height in all cylinders, if the pistons have not been removed; check the compression chamber height by means of pressed-out lead in two cylinders only. See that the compression chamber height corresponds to the value specified in the diesel engine Service Log for these cylinders;

(l) check the fuel injection advance angles;

(m) fit the limiting ring on the cover of the main drive upper gear, and cover the end faces of the torsion shafts;

(n) connect the speed control servo-motor to the governor and the air pipeline;

(o) close the covers of the planetary mechanism handholes;

(p) attach the diesel engine upper covering.

CONNECTING-ROD-AND-PISTON ASSEMBLY

35. Dismount the connecting-rod-and-piston assembly through the lower crankcase side hatch in the following sequence:

(a) remove the covering of the lower crankcase side hatch;

(b) arrange the crankpin bearing of the cylinder to be disassembled in a position convenient for disassembly;

(c) unlock the nuts of the studs which hold the connecting rod pivot to the big end, after which unscrew the nuts first by means of splined wrench 47 [illegible] 232-304, and then with the aid of wrench 47[illegible]-252-305;

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(g) mount [illegible]
inside the lower
backless of the
pass the wire rope over
side of the lower

(e) arrange the crank

In this position tighten
locks and move the big end stud
hammer slightly against the connecting
surfaces of the connecting rod pivot and
keep the piston with the connecting
crankpin lowers down, then overruns the
engine.

(g) Install carriage 47B-232-500 on the web
47B-232-252-1 down between the carriage slides and secure it to the
connecting rod passes into the crankcase between the carriage, while the piston trunk lower end
face rests on the carriage;

(h) slacken the rope with the aid of the winch and lower the piston slowly in such a way that the
the lower end face of the sleeve;

(i) turn the crankshaft until a clearance is formed between the upper end face of the trunk and

(j) move the piston with the connecting rod along the carriage towards the hatch, inclining it to
yourself and take it out of the crankcase by means of lifting fixture 47B-232-165;

(k) remove carriage 47B-232-500 and trough 47B-232-252-1. Close protection to [illegible]
removing the upper piston through the lower crankcase hatch, fit protective rod 47B-232-090 so as
to prevent the studs that hold the big end to the connecting rod blade from being damaged during
rotation of the crankshafts.

36. Dismounting of the upper connecting-rod-and-piston assembly may be carried out in two
ways:

(a) through the lower crankcase, after the respective lower connecting-rod-and-piston assembly
has been taken out;

(b) through the upper crankcase, after the upper crankshafts have been removed.

Removal of upper connecting-rod-and-piston assemblies through the lower crankcase without
removing the upper crankshaft is done [illegible] only as necessary to take out not more than four
upper connecting-rod-and-piston assemblies.

37. To take out the upper pi

(a) take out the respective pi

(b) clean the sleeve contamin

(c) wash cloth soaked in solvent,

(d) lubricate and coat the [illegible]

(e) line up piston with the

(f) [illegible]

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that the locking pins are in the slots made in the bosses of the connecting rod bolts. The marking for on the upper half of the big end and the [illegible] the cylinder to which they pertain must face the turbo-supercharger;

(b) lubricate the connecting rod bolt nuts and the [illegible] the engine, screw on the nuts as far as they will go without [illegible] with a 200 mm long arm, give the nuts one extra [illegible] again; then tighten up the nuts alternately through [illegible] sequence), after which make sure that no clearance is left in the joints between the big end and cap; a 0.03 mm thick feeler gauge should not pass;

(c) measure the clearances between the non-working half-bush and the shaft crankpin on both sides of the bearing (with the crank being in the bottom dead centre). The clearances must correspond to the values indicated in the table of clearances; the difference in the clearances on both sides of the bearing should not exceed 0.03 mm.

Forelock the nuts of connecting rod bolts;

(d) fit the oil-control, protective and compression rings on the pistons by means of piston ring remover and inserter 61B-232-039. Insert two oil control rings into the first (from bottom) piston trunk groove, and fit protective rings into the second and third (from bottom) grooves.

When fitting the oil-control rings on the piston, make sure that the recesses made in the ring sides were directed to one another.

Never insert the rings with their joints through the connecting rod blade, so as to prevent breakage of the rings.

Make sure that the piston rings move freely and without jamming inside the grooves, and that the clearances between the ring and the groove are within the values indicated in the table of mounting and operation clearances (Appendix 6).

Turn the ring joints on the piston through 180° relative to each other, and arrange them along the diesel engine axis. Lubricate the rings and the trunk with oil;

(e) mount appliance 47B-232-049-1 for inserting the piston into the cylinder;

(f) move the piston with the connecting rod through the lower crankcase hatch and fit it on carriage 47B-232-500. Pay herein attention to see that the marking which indicates the belonging of the piston to this particular cylinder faces the turbo-supercharger, and that the recesses for the injector spray cones made in the trunk head are directed endside;

(g) shift the piston on the carriage under the sleeve;

(h) fit split taper ring 61B-252-027 on the sleeve lower part;

(i) pull the piston up by means of the winch and insert it into the sleeve;

(j) turn the crankshaft with the aid of the shaft [illegible] for fitting the connecting rod pivot on the big end;

(k) mount the compression plate on the big end;

(l) lower the connecting rod with the piston [illegible] that the big end studs get freely into the recesses;

(m) remove the grip, pulleys and winch;

(n) turn the crankshaft with the aid of [illegible] a position convenient for tightening up the nuts.

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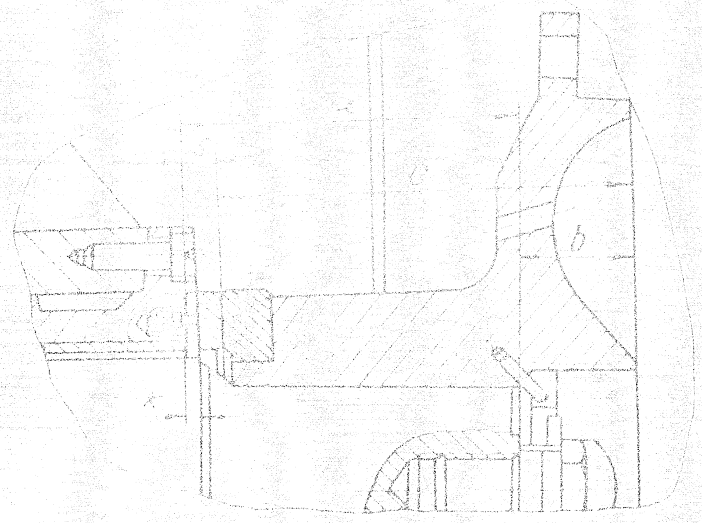
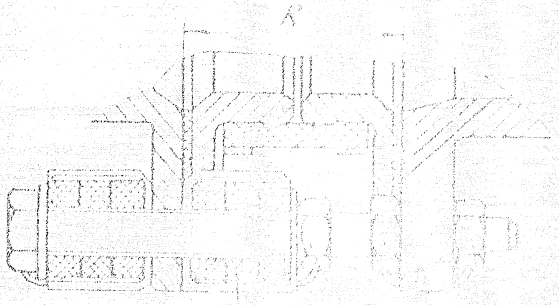
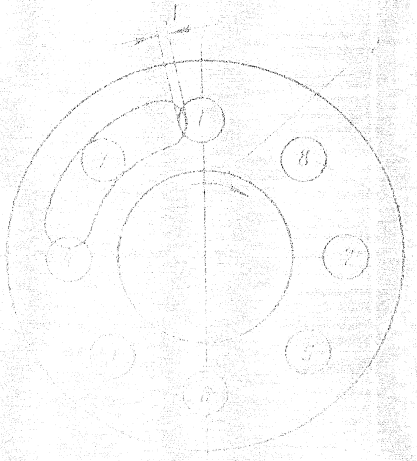


FIG. 8





...DISTRIBUTOR SLIDE
...TO THE FIRST CYLINDER
...CLOCKWISE ROTATION

...direction of rotation; 2 — direction of air distribu...
...slide valve rotation; 3 — drum holes.

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D. Overhauling the Seals of Fresh and Sea Water Pumps

84. Overhaul the seals in case more than 15 drops of water leak from the fresh water pump per minute, or if more than 30 drops leak from the sea water pump.

85. The seal is to be overhauled in the following order:

(a) drain water out of the respective system (refer to para. 80);

(b) disconnect the pump suction and delivery pipelines and seal them off by means of plugs;

(c) mark the mating surfaces of the pump housing, volute and suction pipe;

(d) remove the pump suction branch pipe;

(e) unlock the plate washer, then release and remove the nut (splines);

(f) press off the impeller with the aid of puller 47Д-232-064;

(g) take the sealing ring off the pump shaft;

(h) use puller 47Д-232-085 to press out the oil seal bushing with the graphite ring glued into it;

(i) clean the joints of the housing parts, remove the remaining sealing compound from the joint faces, and make sure that the centring grooves are free of nicks and galling;

(j) check flatness of the end face and the centring groove of the cap thoroughly;

(k) clean and inspect the other parts.

86. No nicks and notches are allowed on the working surface of steel sealing ring 9.

Prior to fitting the sealing ring on the shaft, lap the ring working surface on a surface plate with a thin layer of paste ГОИ.

The ring should contact the plate by at least 85 per cent of the surface.

Then lap the ring to a wet cast-iron surface plate without any abrasive, until mirror finish of the surfaces is obtained.

87. In case deep notches are found on the working surface of the bushing graphite ring, undercut the surface on a lathe, but do your best to ensure the least possible undersizing of the surface.

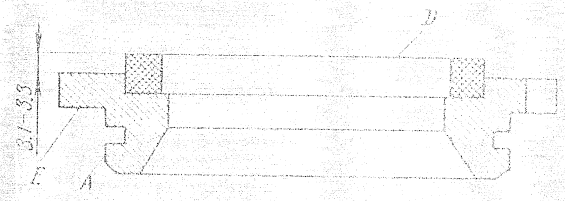

FIG. 85. BUSHING WITH GRAPHITE RING

If the graphite is chipped and cracked, or if the graphite ring projects from the bushing by less than 1 mm, replace the ring. It is allowed to glue a new graphite ring by means of epoxy resin and then to finish the working surface (see Fig. 85).

After the working surface is finished, check the following:

(a) out-of-flatness of surfaces D and E, which should not exceed 0.03 mm;

(b) run-out of surfaces D and E relative to the axis of surface A; run-out is allowed up to 0.025 mm on dia. 50 mm.

Before fitting the seal bushing into the pump cap, lap the graphite ring working surface to a wet cast-iron surface plate without abrasive, until a mirror finish of the surface and a contact of at least 85 per cent are obtained.

Replace the rubber sealing ring by a new one in case it is cut, or if it has lost its elasticity or shape.

88. To assemble the pump, proceed as follows:

(a) fit the rubber ring on the seal bushing, [illegible] of the ring;

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(d) wash the casing interior walls with [illegible]

(e) disassemble the cartridges, remove the [illegible] and clean with diesel fuel, and then arrange with [illegible]

(f) assemble the cartridges. When assembling the cartridges, [illegible] so that the side with the fine mesh screen is [illegible]

(g) mount the cartridges, fill the tubes with oil and [illegible]

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open indicator valve, or stopping the
operation, looseness of the starting
valve.

Remove the defective starting

(c) check sealing of the starting

- set the control selector lever

- supply air at 4 pressures of

- do not push the valve button

- shut off the air supply from

the button as far as it will go and

tion.

(d) check proper connection of

butons, for which purpose compare

air distributor housings.

(e) remove the air distributor

- check setting of air distributor

firing order; bear herein in mind that the

direction of rotation of the upper

- make sure that the supply of air

lar cylinder is in a position of

(f) pressure-test the starting

- Eliminate leakage found during

- To check reliability of the

air from the emergency control

B. Checking Proper Timing of Injection

Fuel injection pumps and Overspeed Governor

To carry out the above

(a) check the control rack

(b) set the governor control

handle in the direction of supply

to 50 per cent.

- in this position:

- the angle between the

lateral shaft key (right) and the

vertical centre line (left), as

viewed in the

- the control rods

- make sure that the

other. If the above requirements

rods (pump body)

between the control

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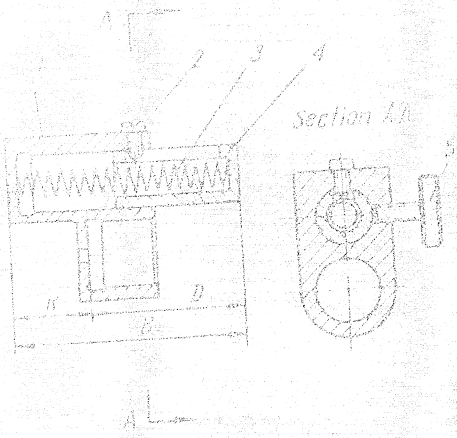

FIG. 57a. CHECKING THE RACK OVERHANG BY MEANS OF APPLIANCE 41H/JF/1981

1 body, 2 screw, 3 = setting, 4 = over 5 = size

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[illegible] governor

[illegible] Angles

[illegible] fuel injection

To check the fuel system for proper [illegible] proceed as follows:

(a) prime the system with fuel by [illegible] fuel feed pump, [illegible] eliminate leakage, if any;

(b) prime the system with fuel until fuel without air bubbles starts flowing out of the pipe union on the uppermost point of the system;

(c) test the pipe union and pressure test the system with fuel at a pressure of [illegible] kgf/cm^2 for 30 minutes; no leakage is allowed.

Note. Due to the fact that some portion of fuel must [illegible] necessary to ensure easy travel of the high-pressure fuel injection pump racks [illegible] the racks during diesel engine operation, insignificant leakage (not more than 3 drops in the course of 5 minutes) is allowed along the racks at rated speed of diesel engine.

(d) adjust the pressure in the system within 140 to 142 kgf/cm^2.

Carry out adjustment of the fuel injection advance angles with regard to the stem fuel injection pumps of the 8th and 16th cylinders in the following sequence:

(a) detach the high-pressure pipe from nozzle and mount appliance [illegible];

(b) set the 8th cylinder stem fuel injection pump [illegible] within 280-0.05 mm by means of appliance [illegible];

When adjusting the fuel injection advance angles, [illegible] the pressure of fuel in the supply pipe line is 1 kgf/cm^2;

(c) turn the crankshafts through 1 or 2 revolutions by means of the shaft barring arrangement and see if the transparent pipe of appliance [illegible] with fuel;

(d) drain part of fuel out of the appliance glass pipe and make sure that the fuel injection pump delivery valve is sealed properly (the level of fuel in the appliance pipe should not increase);

(e) turn the diesel engine crankshafts clockwise with the aid of the shaft barring arrangement [illegible] intermittent short-time engagement of the electric motor), notice the moment when the fuel level (meniscus) in the appliance pipe starts rising, and at the same time cut out the electric motor. In this position determine the fuel injection advance angle by the graduation available on the coupling of the respective lower crankshaft.

The fuel injection advance angles for all the cylinders must correspond to the values specified in the Service Log, and should be within 14 [illegible] 22°. When checking the fuel injection advance angles follow the diesel engine cylinder firing order, [illegible] 1-5-3-7-4-8-2-6 (see Fig. 7-13).

If it is necessary to change the fuel injection advance angle, [illegible] the fuel injection pump, [illegible] the stress of the set of the [illegible] plate springs.

During adjustment, the [illegible] (20±0.5 mm) relative to the rated value (see [illegible]

A 0.25 mm reduction in the [illegible] fuel injection advance angle [illegible] 40 to 42° (20-1.30) to check the [illegible]

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CAUTION:

(d) after [illegible]

the values obtained

CAUTION: [illegible]

(e) during the [illegible]

- write down the position

should be in a position indicated

- check the strokes of the fuel

enter the values into the test certificate [illegible] exceed the values indicated in the Engine Service Log;

8. When running-in the diesel engine at sea [illegible] measure the parameters at steady rating, under the condition that the ship's course is straight and the sea is moderate.

Table 1

Operation rating	Crankshaft speed, r.p.m. (for installations with a variable-pitch propeller)	Duration of operation (hr, min) at rating	Duration of operation (hr, min) total	Inspections
1	2	3	4	5
Operation at mooring trials				
Ahead running, with zero turn of the variable-pitch propeller	300	0 - 15	0 - 15	See Para 5 (a,b)
Ahead running, with the outboard pitch indicator being in a position corresponding to flank speed	350	0 - 15	0 - 30	
Same	480	0 - 20	0 - 50	
Same	510	0 - 30	1 - 20	
Same	560	0 - 40	2 - 00	
Operation at sea trials				
Ahead running, with zero turn of the variable-pitch propeller	300	0 - 10	2 - 10	
Ahead running, with the outboard pitch indicator being in a position corresponding to flank speed	350	0		
Same				
Same				

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1	2	3	4	5
Ahead running, with the outboard pitch indicator in a position corresponding to flank speed				
Same				
Same				
Same				
Same				
Same				See Para 5 (a), (b)
Same				
Same				
Astern running, with the outboard pitch indicator being in a position corresponding to flank speed	300			
	340			
Same	425	0 - 40	15 - 60	See Para 5 (a), (b), (c), (d), (e)

Table 1

Operation rating	Crankshaft speed (r.p.m.) for ahead operations with a variable pitch propeller	Duration of operation (hr:min)		Inspections
		at rating	total	
1	2	3	4	5
Operation at mooring trials				
Ahead running, with zero turn of the variable pitch propeller	300	0 - 10	0 - 10	See Para 5 (a), (b)
Ahead running, with the outboard pitch indicator being in a position corresponding to flank speed	350	0 - 15	0 - 25	
Same	380	0 - 20	0 - 45	
Same	420	0 - 20	1 - 05	
Same	450	0 - 20	1 - 25	
Same	480	0 - 20	1 - 45	
Same	510	0 - 30	2 - 15	
	560	0 - 45	3 - 00	

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APPENDICES

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Appendix 1

OIL FILLING AND MAINTENANCE INSTRUCTIONS

1. Fill the governor with grade 20 (12 cSt at 100°C) oil, GOST 1013-49. The governor needs 4 kg of fresh and thoroughly filtered oil.

The following grades of foreign oils may be also used for the governor:

(a) Great Britain (BP) – Energol DieselSt SAE 40;

(b) U.S.A.: (Esso Petroleum Co. Ltd.) – Esso Lube SDX 30, (Shell) – Rimula 40; (Texas Company) Ursa Oil, Super Duty SAE 40.

2. To prime oil, use row appliance (Fig. 59, No. 252-014 into the hole of the governor upper cover. Fill the oil by separate portions equal to the capacity of cup 22-232-014, with intervals of 8 to 10 minutes.

3. Prime the governor with oil until it reaches the central mark made on the oil level indicator. After a short period of operation, when all the governor cavities get filled with oil, the level of oil lowers down and, therefore, add oil again until it reaches the central mark of the oil level indicator.

4. During governor operation, watch to see that the level of oil does not lower down below the lower mark made on the oil level indicator.

5. Change the oil and wash the governor only on a warmed inoperative diesel engine.

To change the oil, proceed as follows:

(a) drain the oil completely out of the governor through the lower drain plug;

(b) fill the governor with [illegible] until it reaches the upper mark of oil level indicator;

(c) start the diesel engine [illegible] for a period of 1 to 2 minutes;

(d) stop the engine, drain fuel [illegible] governor, flush the latter with fresh oil, then start the engine again and run it idle during [illegible] minutes;

(e) empty the governor and refill it with fresh oil again.

6. During engine operation it is allowed, if necessary, to change the governor rate of irregularity, with the speed control handle position being constant. To this end, turn worm 3 (Fig. 59) of the mechanism for changing the rate of irregularity, by means of a screw driver.

7. During unsteady diesel engine operation at low and idle speeds it is permissible to adjust the opening of the isodrome needle. This adjustment is to be carried out on a warmed operating diesel engine by turning the needle with the aid of a screw driver. Decrease of the isodrome needle opening improves the stability of diesel engine operation; however, too small opening of the needle increases

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Main Troubles, Their Causes and Remedies

Cause	Remedy
1. Diesel engine gets started with a [illegible] to the direction of fuel increase, but runs [illegible]	
(a) insufficient amount of oil in the governor	[illegible] up oil necessary [illegible]
(b) wrong clearances between load limiter forked lever and speed change sensor thrust plate	[illegible] the speed control handle to the governor end lever, and check the [illegible] correspond to the value [illegible]
	Before adjusting the sensor clearance, make sure that the linkage of the speed control handle has not been disturbed.
	To this end, shift the handle to division "9" of the speed scale.
	If the carriage does not obtain herein horizontal position, check engagement of the gear cut on the end of the speed indicator shaft. Eliminate the detected fault, and only then start adjusting the clearance;
(c) governor drive out of order	(c) remove the governor upper cover and see if the speed change sensor rotates during rotation of the drive. If the cup does not rotate, check the parts of the governor drive and the speed change sensor drive for proper functioning.
(d) servo-motor jammed	(d) disconnect the rods from the governor servo-motor shaft and set the speed control handle to any scale division, save for division STOP.
	Then turn the lever on the servo-motor shaft in the direction of fuel feed increase and see if the servo-motor is jammed. In case the servo-motor is jammed, remove the governor from the diesel engine, disassemble it and eliminate the fault.
2. Diesel engine fails to stop with the speed indicator pointer in position STOP. The load indicator pointer fails to approach herein its extreme position by more than three divisions.	
(a) insufficient amount of oil in governor	See Para 1c
(b) wrong clearances between load limiter forked lever and speed change sensor thrust plate	See Para 1b
(c) servo-motor jammed	See Para 1d

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3. Diesel engine [illegible] load (a) governor speed change [illegible] damaged (b) [illegible] damaged (c) servo-motor [illegible] damaged	[illegible] Group Refit [illegible] as indicated in Para 16 [illegible] the linkage to the governor servo-motor [illegible] the rods from the governor [illegible] determine the place of jamming, and eliminate it
4. Diesel engine fails to develop [illegible] speed scale (a) speed control mechanism [illegible] adjusted	[illegible] speed control handle pointer set to Division "16" of the speed scale. Check connection between speed control handle and speed control mechanism; if necessary, eliminate the defect, or adjust the position of the speed-change sensor spring upper holder. Bear herein in mind that one clockwise turn of the holder changes the diesel engine speed by about 8 r.p.m.
5. Too high consumption of oil in governor (a) leather cup of governor driving shaft oil seal loose	(a) carry out partial disassembly of the governor base to replace the drive lower oil seal in compliance with Section "Disassembly of Governor", and eliminate the fault
6. Drive from governor to fuel injection pumps vibrates; load indicator pointer flutters considerably	In all cases, before taking any measures, run the started engine for some period to heat the oil
A. The vibrations are of regular nature in time with engine operation. They are usually most strongly felt at low loads and speeds (a) irregular fuel feed into diesel engine cylinders	(a) use appliance 65-232-045 to check proper engagement between fuel injection pump racks and control rod carriers
(b) clearances in governor drive	(b) remove the governor and check free travel of coupling 30 and sponed shaft 16 (see Fig.14b)
(c) speed-change sensor vibration damper jammed	(c) disassemble the governor as indicated in Para 16a, and eliminate the fault
(d) isodrome needle misadjusted, or air got into governor cavities;	[illegible] the isodrome needle by means of a screw driver through 2 or 3 [illegible] then after 3 - 5 min turn the crankshaft [illegible] operation of engine at low [illegible]

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Cause	Remedy
(b) thermal system leaky, or micro-switch damaged	(b) replace the temperature relay
(c) one of the conductors [illegible]	(c) check connection of conductors
2. Excessive range of [illegible]	[illegible] deviation of operation temperature
(a) rods jammed, or micro-switch damaged	(a) replace the temperature relay
Control circuit for [illegible] pressure sensor	
3. No signal comes up although the pressure in the [illegible] has reached the maximum value	
(a) relay disadjusted	(a) adjust the relay in accordance with instructions available on the relay cover
4. Excessive range of insensitivity or considerable deviation of operation pressure	
(a) rod jammed	(a) replace the minimum pressure relay
(b) friction in mechanical system	(b) replace the minimum pressure relay
(c) micro-switch faulty	(c) replace the minimum pressure relay
Signal panel	
5. Green (or red) lamp fails to come up, though supply has been cut in by PANEL SUPPLY switch	
(a) lamp blown	(a) replace the lamp
(b) switch damaged	(b) inspect and correct the switch
(c) fuse blown	(c) replace the fuse
6. Working condition green tell-tale lamp does not get switched over to red lamp after signalling system sensor operates	
Tell-tale lamps do not come up	
(a) individual point relay faulty	(a) set the control switch to the No. of this group (the groups are counted in accordance with the location of tell-tale lamps on the panel, beginning with the right hand upper lamp). If this fails to ensure a change of signals, replace the relay
(b) external circuit wires out of order	(b) check the wiring and eliminate the fault
7. Red lamp or decoding tell-tale lamp does not shine up after signalling system sensor operates	
(a) lamp blown	(a) replace the lamp
(b) some individual point relay contacts burnt	(b) [illegible] the relay

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Minimum fresh water flow	Fresh water pressure relay
Engine oil outlet temperature	Oil temperature relay
Engine fresh water outlet temperature	Water temperature relay

Fresh water pressure relay	Fresh water pipeline
Oil temperature relay	Oil system, engine oil outlet pipeline
Water temperature relay	Water system, engine fresh water outlet pipeline

Appendix 4

SPECIFICATIONS OF FUELS

Specifications	GOST and values for various grades			Test methods
	GOST 4749-49		GOST 305-62	
	2D	2D	C	
1	2	3	4	5
Cetane number	50	45	50	GOST 3122-52
Fractional composition:				
50 per cent is distilled at a maximum temperature of °C,	280	290	250	
90 per cent		330		
96 per cent	340			
98 per cent	-		340	
Kinematic viscosity at 20°C, c/st.	-	3.5-8.0	1.5-8.0	GOST 33-53
Kinematic viscosity at 50°C, c/st.	2.5-4.0			GOST 33-53
Coking capacity of a 10-per cent residue, per cent (max)	0.5	0.5		GOST 19-57-51
Maximum acid number, mg per 100 ml of fuel	5			GOST 5-53-52
Maximum ash content, per cent	0.02	0.02		GOST 1461-52

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			5
Mechanical impurities, %			GOST 1771-47
Sulfur, per cent			
Copper strip test			GOST 6321-52
Minimum flash point, °C			GOST 6356-52
Maximum freezing point, °C			GOST 1533-42

Appendix 5

SPECIFICATIONS OF OILS

Specification	Test method
Specific gravity	GOST 3-66
Kinematic viscosity at 100°C, Cst	GOST 1461-59
Minimum ash content, per cent	GOST 6370-59 (and washing the filter additionally with hot water)
Maximum content of mechanical impurities, per cent	
Maximum water content	GOST 2477-65
Minimum open-cup flash point, °C	GOST 4333-65
Maximum congealing point, °C	GOST 1533-42
Oil coking capacity	GOST 5987-51

Appendix 6

MOUNTING AND OPERATING CLEARANCES

Description of clearance	Shaft clearance, mm	Bearing metal clearance, mm	Maximum permissible during operation
1	2	3	4
Diametral clearance in main bearings (as measured with feeler gage)	0.24	0.28	0.40
Clearance under lower collar of main bearings (as measured with feeler gage)	0.20	0.25	
Side radial clearance in the joint of main bearings at distance of 20 mm from the joint face:			
for half bushes bearing on the joint face			

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			0.40
			0.5
Working cylinder sleeve			
Clearance between cylinder sleeve and liner with jacket and frame along the ring collars (from top to bottom):			
collar I, dia.325 - along the sleeve flange	0.09	0.225	
collar II, dia.318 - along jacket top	0.020	0.09	
collar III, dia.315 - along jacket bottom	0.020	0.09	
collar IV, dia.263 - along sleeve bottom	0.09	0.175	
Clearance between piston guiding part and cylinder sleeve (difference between maximum diameter of piston and minimum diameter of sleeve)	0.39	0.435	0.7
Piston, connecting rod			
Diametral oil clearance in end bearing (in vertical plane), as a caution with feeler gauge	0.18	0.26	0.40
Diametral clearance between piston pin and piston insert hole	Clearance	Clearance	
	0.050	0.080	
Axial play of connecting rod in piston insert, as measured with feeler gauge			1.0
Diametral clearance between piston trunk and insert along the centering collars (as measured):			
along upper collar	0.10	0.16	
along lower collar			

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1	2	3	4
Clearance between compression ring and piston groove (in width), as measured with feeler gauge			0.40
Clearance between protective ring and piston groove (in width), as measured with feeler gauge			0.40
Gap of compression and protective rings:			
compressed gap (according to feeler gauge)			3.0
free gap			at least 18
Clearance between oil-control rings and piston groove (in width), as measured with feeler gauge	0.05	0.12	0.25
Oil-control ring gap:			
compressed gap (according to feeler gauge)	1.3	1.8	3.0
free gap	21	24	at least 18
Distance between piston heads (according to pressed-out lead)	3.0	3.5	
Camshaft bearings			
Camshaft bearing diametral clearance measured with feeler gauge	0.06	0.11	0.25
Axial play of camshaft in thrust bearing	0.4	0.7	1.00
Main drive			
Diametral clearance in bearings of upper and lower gear shaft journals, as measured with feeler gauge	0.3	0.4	0.6
Diametral clearance in bearings of gear shaft journals (as measured with feeler gauge)	0.2	0.3	0.5
Axial clearance (total) in thrust bearing	0.5	0.7	1.0
Axial clearance of intermediate shaft	2.0	3.0	
Water pump drive			
Backlash between teeth of 2nd stage driven gear and last intermediate gear	0.15	0.34	
Backlash between teeth of flat coupling drive intermediate gears			clearance of coupling as compared with [illegible]
Backlash between teeth of [illegible] mediate and driving gears of [illegible] drive			

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Axial play of the [illegible] bearing			
Radial clearance between [illegible] bearing			
Axial clearance between [illegible] on impeller and supporting [illegible] according to pressed-on [illegible]			
Axial clearance between supercharger impeller and supercharger casing rear wall (as measured with feeler gauge)			
Radial clearance between turbine blade edges and guide vane assembly, as measured with feeler gauge			
Axial clearance between impeller disc and turbine nozzle diaphragm assembly, as measured with feeler gauge	0.6	0.9	
Axial negative allowance of fluid coupling driven rotor on turbo supercharger shaft cone	0.5	0.5	
Clearance between fluid coupling driving and driven rotors on the bow side	1.2	2.2	
Total axial clearance of driving rotor	4.0	5.0	
Clearance between the bow end face of bearing bushing and the respective end face of the gear	0.6	0.9	2 – 10

Appendix 2

RATED WEIGHTS OF DIESEL ENGINE MAIN UNITS AND PARTS, AND OF THE FURNISHED EQUIPMENT

Name of units and parts	Weight, kg
Frame complete with lower crankshaft, [illegible] but without working cylinder sleeves and gas exhaust [illegible]	13,200
Main drive assembly	1,000
Accessory drive assembly	2,050
Upper covering	380
Engine sump	400
Crankshaft with damper	1,420
Piston complete with connecting rod [illegible]	105

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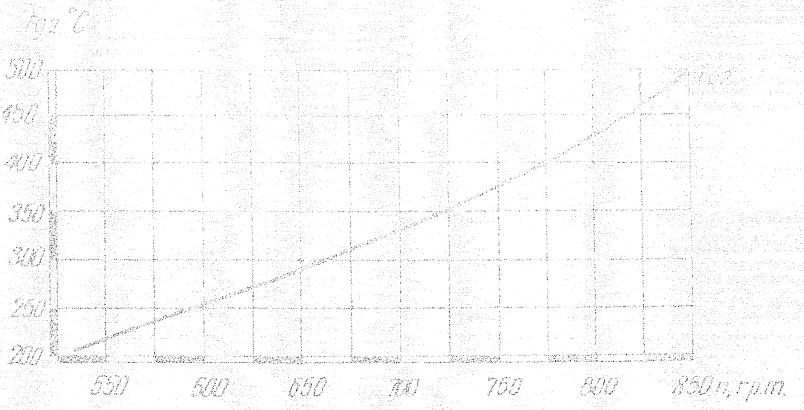

FIG. 89. CHART SHOWING CHANGE OF EXHAUST GAS TEMPERATURE UPSTREAM OF TURBINE DEPENDING ON SPEED AT PROPELLER PERFORMANCE (ULTIMATE VALUES)

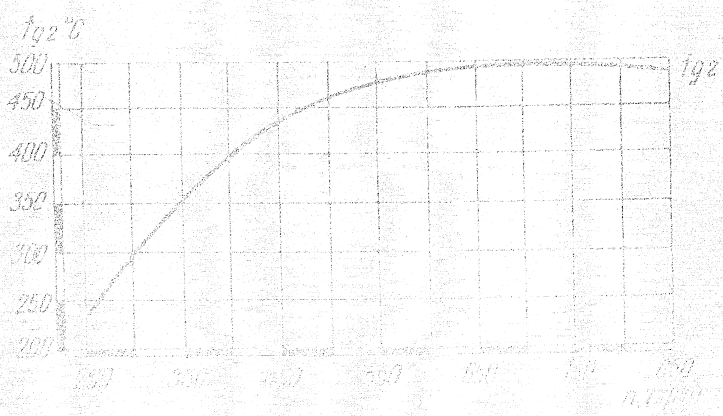

FIG. 90. CHART SHOWING CHANGE OF EXHAUST GAS TEMPERATURE UPSTREAM OF TURBINE DEPENDING ON SPEED AT PROPELLER PERFORMANCE (CRUISING VALUES)

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Unit or part	Place of measuring	
Camshafts	Side surface of a lobe (flange)	Starboard row: 1L (right-hand), 2L, 3L, etc. Portside row: 1L (left-hand), 2L, 3L, etc.
Camshaft bearings	End face, bow	Starboard row: 1L, 2L, 3L, etc. Portside row: 1L, 2L, 3L, etc.

Appendix 9

CHARTS SHOWING CHANGE OF EXHAUST GAS TEMPERATURE UPSTREAM OF TURBINE DEPENDING ON SPEED AT PROPELLER AND LIMITING PERFORMANCE

(See Figs. 89, 90)

Appendix 10

DIESEL ENGINE UNIVERSAL PERFORMANCE WITH REGARD TO RELATIVE HOURLY CONSUMPTION OF FUEL

During diesel engine operation at any rating its power is determined with a quite sufficient accuracy by the relative hourly consumption of fuel.

The relative hourly consumption of fuel is determined from the formula:

$$K = \frac{G_f}{G_{fn}}$$ (see Fig.91), where

G_f - hourly fuel consumption measured at this particular rating;

G_{fn} - hourly fuel consumption at nominal rating, as specified in the diesel engine Service Log, and brought to ship's conditions (depending on heat capacity, intake temperature and exhaust back-pressure as indicated in Para.71, Chapter II).

The engine power is calculated from the determined value of relative hourly consumption of fuel (K) and diesel engine speed (n) at this particular rating.

Note. The fuel consumption is to be checked at diesel engine constant speed and load (with the sea being smooth or slight, and the ship's course straight). Measure the fuel consumption at least three times, then calculate the mean result, so as to avoid errors.

Appendix 11

INSTRUCTIONS FOR REMOVING CARBON FROM PISTONS

To remove carbon from pistons, apply chemical and mechanical methods, and strictly follow the directions given in the instructions below.

Chemical cleaning is done with a 15-per cent alkali solution of caustic soda (NaOH) or caustic potash (KOH) in water.

Preparing the Solution

1. Weigh up the necessary amount of alkali (in compliance with the capacity of the bath).

2. Fill half the bath volume with cold water, and add the alkali carefully into it.

3. Add water up to the working level, stir the solution and heat it up to a temperature of 90° to 100°C.

Note. Arrange exhaust ventilation above the bath with the alkali solution.

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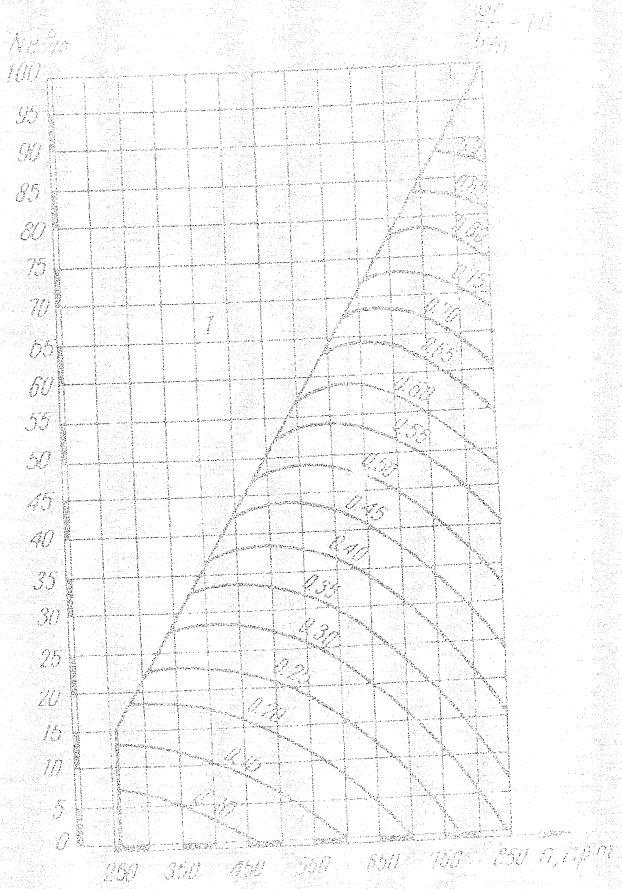

FIG. 51. DIESEL ENGINE UNIVERSAL PERFORMANCE VIEW CURVES RELATIVE HOURLY CONSUMPTION OF FUEL

1 — outer (loading) performance curve

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Removal of Carbon

4. Dip the pistons (with [illegible]

5. Keep the pistons in [illegible] for 30 to 40 minutes at a temperature of 90° to 100°C, after which [illegible]

To this end:

(a) take the piston out of the bath with [illegible] cooler bath containing cold water and keep the piston in the bath until [illegible] completely;

(b) remove the remaining carbon by cleaning the piston with the aid of stiff hair brushes or wooden scrapers.

Note. Never remove carbon by means of metal tools which may damage the piston surface.

6. If carbon has not been removed completely, submerge the pistons into the bath with hot solution again, and keep them there for 10 to 15 minutes.

7. Having washed the pistons with cold water, blow them out with dry compressed air, and then wash them with diesel fuel or kerosene.

8. Change the alkali solution as soon as it becomes dirty, but only after one set of pistons has been washed.

Appendix 12

INSTRUCTIONS FOR MAINTENANCE OF OIL, WATER AND AIR COOLERS

1. When mounting the oil and water coolers, observe the following conditions:

(a) install the cooler in such a way that its housing gets completely filled with sea water during operation (this is to be born in mind when installing the cooler above the water line);

(b) when connecting the cooler to the ship's systems, never tighten up the flanges so as to ensure alignment of bolt holes;

(c) when installing the cooler, take care to ensure:

- access to the protectors and to the plugs for bleeding the air and draining the water and oil;
- drainage of water and oil through the lower plugs;

(d) fit a screen filter capable of trapping particles larger than 1.5 mm into the pipeline which feeds sea water to the cooler.

If leakage is found in the tube plate, solder the leaking place by means of [illegible] solder.

In case leaky pipes are detected (provided the quantity of such pipes does not exceed 5 per cent of the total number of pipes), solder the damaged pipes on both ends. Replace the cooler if the quantity of damaged pipes exceeds 5 per cent of the total number of pipes.

After soldering is accomplished, carry out hydraulic test of the sea water cavity at a pressure of 5 kgf/cm^2 in the course of 30 minutes.

Fit the cooler covers into place through new gaskets, and take care to see that the thickness of the circular gaskets placed between the [illegible] is [illegible] and equal to the thickness of the strip-type gaskets placed between the [illegible] and the tube plate, but is larger by 0.1 - 0.2 mm.

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Removing, Disassembling and Washing the Oil Cooler

1. Disconnect the sea and fresh water pipelines from the cooler.
2. Detach the upper and lower covers from the cooler.
3. Arrange the cooler so that one branch pipe faces up. Close the other branch pipe by means of the blind flange, and fill the cooler housing with washing solution.
4. Further operations are the same as when washing the oil cooler.

Removing, Disassembling and Washing the Air Cooler

1. Disconnect the sea water pipelines from the cooler.
2. Detach spacer 11 from lower cover 5 and housing 3 (Fig.2).
3. Unscrew the nuts of the studs which hold the upper cover to the cooler housing.
4. Screw two eye-bolts M10 into the upper tube plate through the upper cover hole and take the heat exchanging unit out of the housing.
5. Secure the upper cover to the tube plate by means of bolts and nuts.
6. Arrange the cooler so that the sea water branch pipes face upwards and fill the heat exchanging unit with washing solution.
7. Further operations are the same as when washing the oil cooler.
8. After washing is accomplished, subject the sea water cavity to hydraulic test at a pressure of 3 kgf/cm^2 in the course of 10 minutes. No leakage is allowed.

Note. Remove the protectors from all the coolers (oil, water and air), clean them until bright, and then fit into their places. In case the protectors have lost more then 50 per cent of their volume, replace them by spare ones.

This method of washing the sea water cavities is advisable for application during engine repairs or preventive maintenance.

Second Method

The washing arrangement presented in Fig.92 makes it possible to wash the coolers (sea water cavities) without dismounting them from the cooling system, so as to reduce labour consumption.

Carry out washing in the following sequence:

1. Close sea water pipeline shut-off valves 1 and 2.
2. Screw out lower drain plug 3 and let sea water out of the cooler housing. After water is drained, screw the plug into its place.
3. Attach hoses 4 and 5 to valves 6 and 7 as shown in the diagram (Fig.92); see that valves 6, 7, 11, 12 and 14 are closed. Screw out plug 8 and screw in the end piece of gas outlet hose 9 instead of the plug. Screw out the protectors and screw in spare pipe inserts instead of them.
4. Open valves 6 and 12 and let washing solution fill up the coolers by gravity. Watch evolution of gas from cooler into tank through hose 9 for which purpose the hose spout into the remaining liquid tion of the solution.
5. As soon as evolution of [illegible] ceases, as a rule, not more than 20 to 30 minutes, close valve 6 and drain the washing [illegible] the lower cover drain hole [illegible] closed.

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First Method

When applying this method, remove the oil cooler from its seat and disassemble it as described in Section A. To carry out washing, submerge the cooling element with the body into a tank with chemical solution. Use carbon tetrachloride or gasoline as solvent.

The use of gasoline is undesirable for fire-prevention reasons. To wash the cooling sections with carbon tetrachloride solution, proceed as follows:

1. Dip the cooling element with the body into the tank with solvent and keep it there in the course of 10 to 15 minutes. During this period lift and lower the section several times to wash the pipes (until clarified solvent starts flowing out of the pipes).

2. Arrange the cooling element with the body above the tank and force solvent through each pipe by means of a gun with a spout having the shape of the pipe slot.

3. Wash the cooling element with the body by submerging it into hot water, after which place it vertically so that water drips down.

4. Examine the pipe ends. If the pipe ends are choked with hard particles, remove the particles with the aid of a metal needle, or by scavenging the pipe with compressed air, after which wash the cooler with hot water again.

5. Assemble the cooler and pressure-test the oil cavity with motor or solar oil at a pressure of 8 kgf/cm^2 for 5 minutes. No leakage is permissible.

Second Method

With this method applied, the cooler needn't be disassembled; the cooler pipes are washed by means of a special stand whose diagram is presented in Fig.94.

Washing is to be carried out in the following sequence:

1. Dismount the cooler from its seat and drain the oil out of the pipes (or do not dismount the cooler, and use flexible hoses to drain the oil).

2. Mount the cooler on the washing stand and connect the cooler oil system to the circulating system, as indicated in Fig.94.

3. Use pump 2 to force washing solution through the cooler pipes for 30 minutes in the direction opposite to the oil flow, and for 30 minutes in the direction of oil flow.

The water solution used for washing should contain 4 per cent of oxidized petrolatum (Specifications BTV3 45-50) and 5 per cent of caustic soda. The temperature of the solution must not be lower than 93°C and the velocity of its flow through the cooler pipes should be within 1.5 - 1.6 m/sec. (To wash the cooler, use a pump with a capacity of 140 - 180 m^3/hr).

4. Pump hot water (not lower than 80°C above zero) through the cooler pipes in the course of 15 to 20 minutes.

5. Remove the covers from the cooler and scavenge the pipes with compressed air until water is forced out of the pipes.

6. Examine the pipe ends. If the pipe ends are choked with hard particles, remove the particles with the aid of a metal needle, or by scavenging the pipes with compressed air. Put the covers into place.

7. Pressure-test the cooler oil cavity hydraulically by means of motor or solar oil at a pressure of 8 kgf/cm^2 for 5 minutes. No leakage is permissible.

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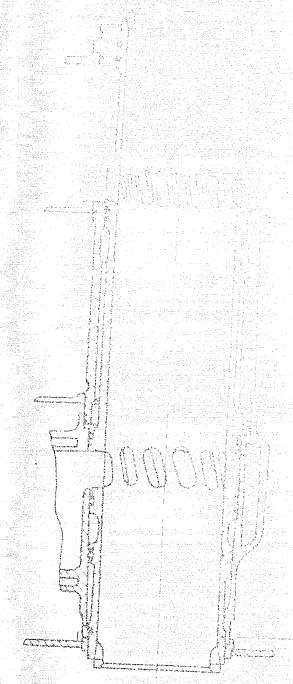

FIG. 95. FITTING THE SLEEVES INTO DIESEL ENGINE FRAME

Preparing the putty

1. Mix the weighed portion of asbestos, crumbled cement thoroughly.
2. Add soluble glass into the obtained mixture and stir until it acquires the necessary plastic consistency.
3. Store the prepared putty in a tightly closed container to prevent its untimely solidification.
4. Apply the putty to the turbine mating surfaces by means of a spatula.

Appendix To

LIST OF MEASURING INSTRUMENTS AND AUTOMATIC SYSTEM DEVICES DELIVERED WITH DIESEL ENGINE

Nos	Instrument	Position of reading	Only per engine	Standards	Notes
1	2	3	4	5	6
1	Pressure gauge MTK-100Gx60 accuracy class 2.5 (for starting air)	30	1	2825-054-11024	On instrument board (near engine)
2	Pressure gauge MTK-100Gx10 accuracy class 2.5 (for oil)	6	1		
3	Pressure gauge MTK-10[illegible] accuracy class 2.5 (thermometer) tion and control)	4	1		

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1	2	3	4	5
13	Pressure gauge MTK-100 type I, 0 – 6 kgf/cm² (for fresh and sea water)	1	GOST 8625-57	Same
14	Maximum pressure indicator 1711, 160 kgf/cm²	1		Same
15	Marine-type thermometer TK-100-100	1		Same
16	Pressure gauge MTK-100 accuracy class 2.5	1	GOST 2405-57	Same
17	Signal panel	1	ShU-510-60.2	Same
18	Signal box	1	ShU-511-60.2	Same
19	Combination relay KP-1 with temperature sensor:			
	(a) with a setting above 95°C (for oil)	1	TU 38.321 80.2-60	Same
	(b) with a setting above 80°C (for water)	1	Same	Same
20	Combination relay KP-1 with pressure sensor set up for operation:			
	(a) at a drop of pressure below 2 kgf/cm² (for oil and fuel)	2	Same	Same
	(b) at a drop of pressure below 0.75 kgf/cm² (for fresh water)	1	Same	Same
21	Combined bell and howler 2GM-24	1	MPT/5.6.07-47008-65	Same

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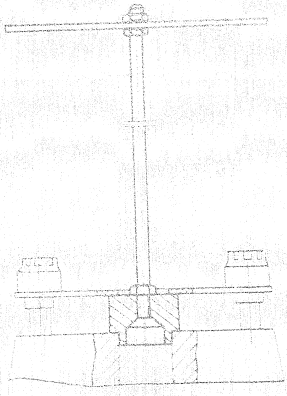
1	2	3
47B-232-498	Wrench for nuts fastening the frame mounts	
47B-232-055-1	Handle for wrenches of jack bolt and locknut	
47B-232-189	Appliance for removing the main bearing bush	
47A-232-090	Protective rod for the connecting rod big end	

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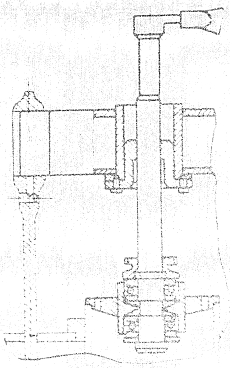
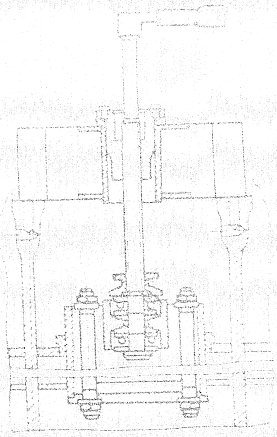
1	2	3
47П-232-079	Puller to press in the working cylinder sleeve	
47П-232-079	Puller to press out the working cylinder sleeve	

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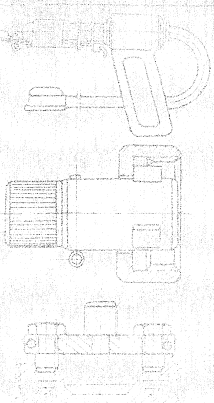
4ГД-252-080	Appliance for inspecting the working cylinder sleeve
4ГД-252-097	Appliance for screwing-in the injector pipe union
4ГД-252-098	Appliance for screwing-in the injector flange
	Appliance for screwing-in the injector pipe union



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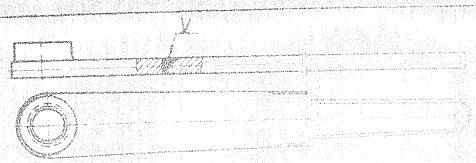
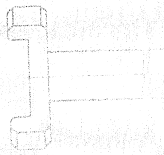
1	2	3
[illegible]	Wrench for screwing-in the injecter pipe union	
[illegible]	Wrench for starting valve pipe union	
[illegible]	Appliance to hold the wanner of working cylinder starting valve flange	

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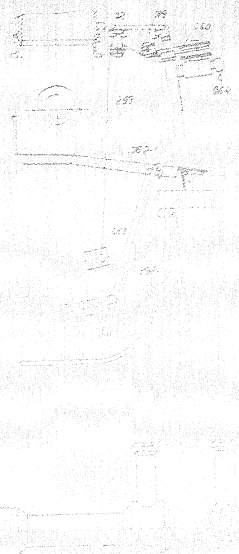
1	2	3
47Д-232-049- -1	Appliance for taking the lower piston out through the lower crankcase	
47Д-232-019	Suspension pulley	
47Д-232-02[illegible]	Suspension pulley	
47Д-232-03[illegible]	Grip assembly	
47Д-232-05[illegible]	Hook	
47Д-232-0[illegible]	Carriage for pistons 1	
47Д-[illegible]	[illegible]	
47Д-[illegible]	[illegible]	
47Д-[illegible]	[illegible]	

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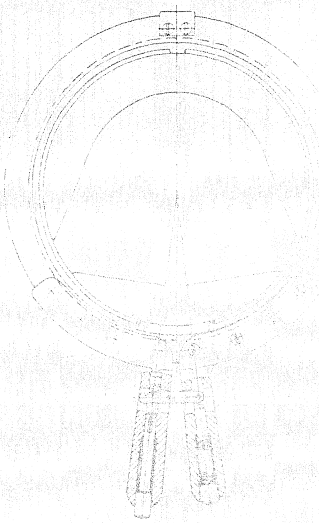
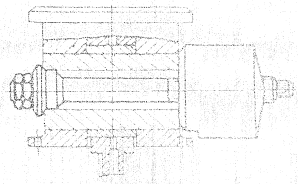
1	2	3
41B-232-039	Compression piston ring remover and inserter	
47B-232-194	Remover to press the pins out of piston insert	

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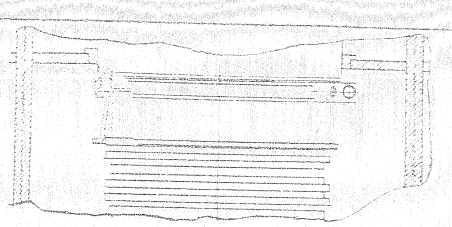
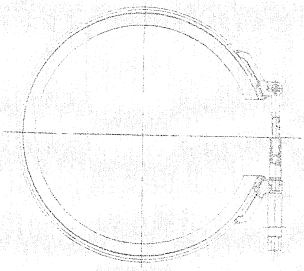
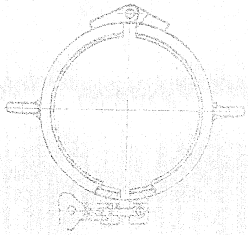
615-252-027 Appliance for fitting the pistons into cylinders





615-252-028 Piston lifting fixture



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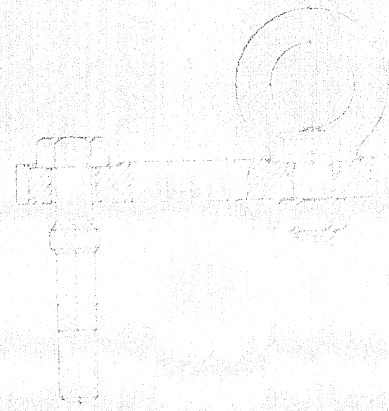
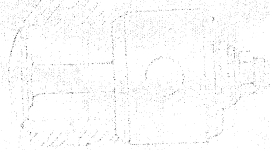
47L-252-042	Master cylinder seal driver	
47L-252-049	Puller to press on the outside- lay rod end bearing cup	
47L-252-089	Puller to press out the rear shoe end bearing pin	

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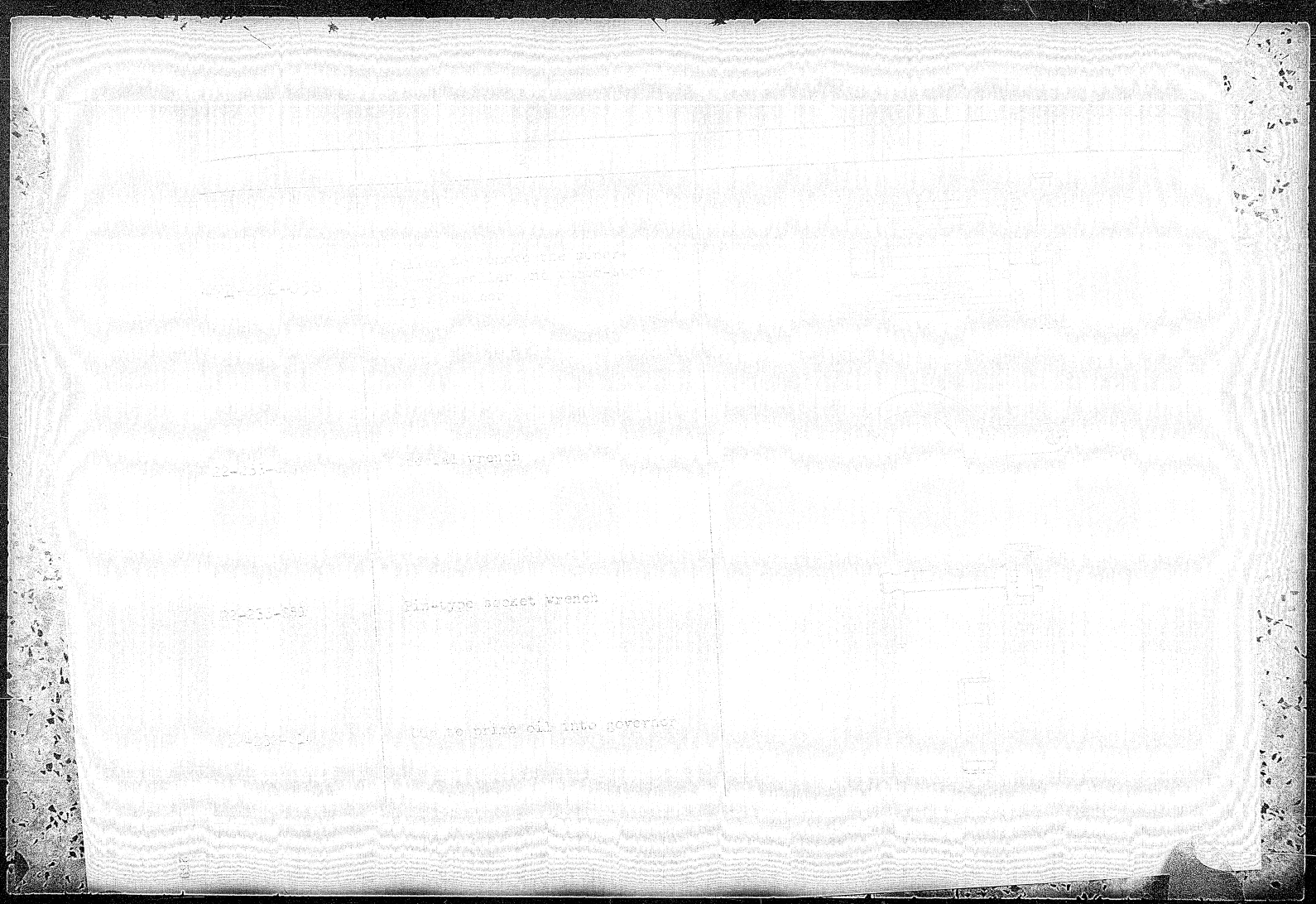

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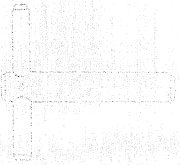

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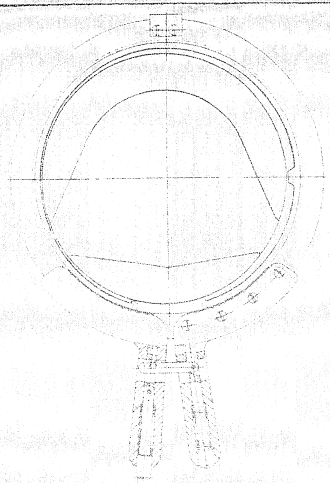
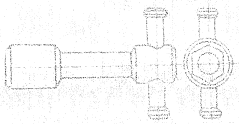
1	2	3
615-2,2-4,5	Oil-control piston ring remover and inserter	

Standard Tools

Double-end flat wrenches: 6 x 8, 10 x 12, 12 x 14, 17 x 19, 22 x 24, 24 x 30, 32 x 36, 36 x 41,	
Socket wrenches: 16, 18, 14, 22, 24, 30,	

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US AND LUBRICANTS

Name of mechanism	Grades of oils or lubricants
Diesel engine 6IB-2	Motor oil MK-22 or MC-20, 12H No.24-63
Speed governor	Oil MK-22 or MC-20, GOST 1013-49
Air distributor	Grade "2" fatty solid oil, GOST 2556-58, or grease 1G-2, GOST 1033-51
Reduction gear of shaft bearing arrangement	Summer grade transmission automobile oil, GOST 542-50
Bearings of shaft bearings arrangement	Lubricant 7Sh (lithol lubricant 1-13, GOST 1631-61
Bearings of control mechanism of remote control gate	Solid oil, GOST 1033-51, or petrolatum, GOST 782-59
Oil seal of regulating valves of thermostats	Grease 1G-2 or 1G-2, GOST 1033-51

INSTRUCTIONS FOR PETROLEUM GRADE

1. Emulsion additive [illegible] Spec. [illegible] corrosion and cavitation wear of the [illegible] hide-[illegible] fluid of dark grey colour [illegible] for the cooling system represent [illegible]

Grease or oil
Grease (Esso) [illegible]
U.S.A. (Esso Petroleum Co. Ltd.) Essolube SDX-50 [illegible]
Great Britain (BP) - Energol [illegible]
D.SAE-30
U.S.A. (Esso Petroleum Co. Ltd.) Essolube HD50 (Shell) - Rotella 50 (Texas Company) - Urea Oil SAE-50
Great Britain (BP) - [illegible]
U.S.A. (Esso Petroleum Co. Ltd.) - Esso Fluid Grease or Nebula A (Texas Company) - Retinax A (Texas Company) - Marfak No.0
Great Britain (BP) - [illegible]
D.SAE-10
U.S.A. (Esso Petroleum Co. Ltd.) Essolube HD10 (Shell) - Rotella 10 - Texas Company) - Urea Oil SAE-10
Great Britain (BP) - [illegible]
U.S.A. (Esso Petroleum Co. Ltd.) - Esso Fluid Grease or Nebula A (Texas Company) - Retinax A (Texas Company) - Marfak No.0

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[illegible] of additive concentration up

[illegible] water taken place during the first 100 hours of

[illegible] is explained by

[illegible] the formation of a protective film to coat the sur-

[illegible]

[illegible] 100 hours of engine operation, fill additive into the cooling system, so that

[illegible] per cent.

During further operation of engine the concentration of additive will remain stable, provided no

[illegible] from the system.

[illegible] cooling system functions normally, it is to be replenished with additive once every

[illegible] of diesel engine operation.

To replenish the system with the aim of making up for the evaporation, use clean water with-

[illegible], since too often introduction of additive into the cooling system is likely to produce ex-

[illegible] protective films on the sleeve walls, and this may worsen the heat transfer.

Keep thorough watch on the sealing of the system, so that no fluid is leaking out of it.

[illegible] never warm the system by supplying steam right into the coolant, as this results in

[illegible] of additive concentration.

The necessary amount of additive to be introduced is determined from the formula:

$$P = \frac{0.5 - K}{100} V \text{ (kg)},$$

[illegible] amount of additive to be introduced, kg;

[illegible] of additive in water according to the results of chemical analysis taken before

[illegible] additive is introduced, per cent;

[illegible] capacity, litres.

[illegible], the content of additive in water is checked approximately by the colour

[illegible] with standard samples containing 1.0, 0.5 and 0.3 per cent of additive.

[illegible] the additive is introduced into the system, and also every 250 hours of diesel

[illegible] once every 3 months, determine the content of additive in water under

[illegible] concentration of additive is found by carrying out titration with 0.1 normal

[illegible] with 2-per-cent water solution of methyloranze. The value of the titer is

[illegible] with an alkaline sample (prepared beforehand) containing 1 per cent of

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Recommended for use are [illegible] AN-VV-570 Soviet Lubricating Oil.

Different grades of this lubricant ought to be used:

(a) lubricant AN-VV-570 with a kinematic viscosity of 20 to 30 cst. at 100°C - for flushing the fuel system and the starting and control mechanisms;

(b) lubricant AN-VV-570 with a kinematic viscosity of 30 to 245 cst. at 100°C - for flushing the diesel engine lubricating system;

(c) lubricant AN-VV-570 with a kinematic viscosity of 40 to 50 cst. at 100°C - for flushing the outer surfaces of the diesel engine and spare parts.

2. Apply the slushing compound by one of the following methods:

(a) mechanical spraying;

(b) priming;

(c) with the aid of a grease gun or brush;

(d) by dipping the separate parts into lubricant.

Never use compressed air during the slushing procedure.

3. In case moisture is found in the slushing compounds, dewater them, for which purpose heat the lubricant up to a temperature of 110 to 120°C and keep it at this temperature until foaming ceases completely.

II. Preparation for Slushing

4. Before slushing the diesel engine inner surfaces, do the following:

(a) pump the oil completely out of the sump;

(b) open the indicator valves, as well as the cocks on the drain pipes of the receiver and exhaust manifolds;

(c) remove the diesel engine upper covering and detach all the covers of the lower crankcase handholes;

(d) empty the fuel system;

(e) empty the water system;

(f) discharge water from the turbo-supercharger bearing cooling cavities through the drain pipes.

5. Prior to slushing the diesel engine outer surfaces, blow out the engine with dry compressed air and wipe the outer non-painted surfaces with cloth soaked in diesel fuel.

III. Slushing the Engine Inner Surfaces

6. To slush the fuel system, proceed as follows:

(a) set the fuel injection pumps to position STOP by means of the emergency control station handle, then prime the system with hot oil heated to a temperature of 50°C at a pressure of 2.5 - 3 kg/cm^2 until lubricant appears from the pipes connected to by-pass valves;

(b) unscrew the high-pressure pipes partially from the injectors, set the fuel injection pump racks on the maximum fuel feed position by means of the emergency control station handle, go on priming the system at a pressure of 2.5 - 3 kg/cm^2 and at the same time turn the crankshaft by means of the shaft-barring arrangement (up to the [illegible] of the lubricant).

Pressure-wash the system until [illegible] appear from the pipes connected to by-pass valves. After priming is accomplished, [illegible]

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Specifications

General Description

Chapter II. DIESEL ENGINE FRAME AND COVERINGS

Diesel Engine Frame

Air Receiver Safety Valve

Coverings of Lower Crankcase Barrel

Upper Covering

Oil Sump

Chapter III. CRANK GEAR

Crankshaft

Connecting Rod

Piston

Torsional Vibration Damper

Chapter IV. GEARING

Main Drive

Minor Accessories Drive

Minor Accessories Drive

Camshaft with Drive

Fuel Injection Advance Angle Adjusting Mechanism

Overspeed Governor Transmitter

Chapter V. GAS-AIR SYSTEM

Working Cylinder

Gas Exhaust Manifold

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Air Cooler with Branch Pipes
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